COMPARISON OF DIFFERENT TONOMETERS

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CERTIFICATE

This is to certify that **Dr.Swathi.N,** Post Graduate student in M.S Ophthalmology, at Regional Institute of Ophthalmology and Government Ophthalmic hospital attached to Madras Medical College, Chennai, carried out this dissertation on **"COMPARISON OF DIFFERENT TONOMETERS"** under my direct guidance and supervision during the period from May 2005 to March 2008.

This dissertation is submitted to the TamilNadu Dr.MGR Medical University, Chennai in partial fulfillment of award of M.S. Degree in Ophthalmology.

Prof. Dr. V. VELAYUTHAM,
Chief, Glaucoma Clinic
RIO - GOH,
Chennai - 8.

Prof. Dr. V. VELAYUTHAM,
Director & Superintendent,
RIO - GOH,
Chennai - 8.

Prof.Dr. T.P. KALANITI, M.D
Dean,
Madras Medical College,
Chennai

DECLARATION

I, **Dr.Swathi.N,** solemnly declare that the dissertation titled **"COMPARISON OF DIFFERENT TONOMETERS"** has been prepared by me. This is submitted to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement for the award of M.S. Ophthalmology, degree Examination to be held in March 2008.

Place: Chennai

Date:

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PART - I

INTRODUCTION

Glaucoma is chronic optic neuropathy characterized by structural and functional damage to the optic nerve head (as evidenced by thinning of the neuro retinal rim and by progressive visual field loss) caused by many factors among which intraocular pressure is an important and critical factor.

While IOP is not the only causative factor, it still remains the only risk factor amenable to and modifiable by treatment and the only indicator which can be constantly monitored at every visit or assessment as a measure of success of treatment.

This study compares the intraocular pressure values obtained by different tonometers and compares the correlation between the values obtained.

AQUEOUS HUMOR

Aqueous humor is secreted by the non-pigmented epithelium of the ciliary processes. It is derived from the plasma with in the capillary network of the ciliary processes.

Mechanism of aqueous humor formation

1. Active transport secretion: - 70%.

An energy dependent process that selectively moves a substance against its electro-chemical gradient across a cell membrane transports water-soluble substances by Na^+ K^+ ATPase Pump.

Site of active transport is considered to be the nonpigmented epithelial cells.

2. Ultrafiltration.

It is the movement of substance along a pressure gradient. Colloid osmotic pressure of tissue spaces is high. So it favors movement of water from the plasma into the ciliary stroma.

3. Diffusion.

It is the energy independent movement of substances across the membrane of ciliary epithelium along its concentration gradient.

Aqueous outflow channels:

1. Conventional outflow

After active secretion by ciliary process, aqueous passes from posterior chamber to anterior chamber through pupil. Aqueous flows out through trabecular meshwork into schlemms canal and into aqueous veins and then to superior ophthalmic vein.

2. Non conventional outflow

1. Uveoscleral / Uveovortex outflow.
2. Exchange across Iris vessels.
3. Corneal endothelial exchange.
4. Exchange across anterior vitreous face.

Factors affecting aqueous humor production

1) Aqueous humor flow has been shown to be reduced in patients with Diabetes mellitus.

2) Aqueous humor production decreases with increase in age, during sleep and during exercise.

3) Inflammation causes the decrease in inflow due to disruption in the ciliary epithelium. It is also reduced during acute phase of hypotony following Cyclodialysis but not with chronic cyclodialysis.

4) It decreases with pharmacological agents – Apart from antiglaucoma medications, General anesthetics also decrease aqueous humor production.

Normal aqueous humor formation - 2.2 µl/min.

Methods of measuring aqueous humor flow.

i) Tonography

ii) Anterior chamber fluorophotometry

iii) Invasive techniques

FUNCTIONS OF AQUEOUS HUMOUR:

1) Maintenance of proper IOP.
2) Provides nutritional substrates to lens and cornea.
3) Removal of metabolites.
4) Aids in metabolism of vitreous and retina as amino acids and glucose pass into the vitreous from the aqueous.

COMPOSITION OF AQUEOUS HUMOUR IN RELATION TO PLASMA

1. Slightly hypertonic
2. Acidic
3. Increased ascorbate
4. Deficit of proteins
5. Slight increase in chloride and lactic acid.
6. Deficient in Sodium, Bicarbonate, Carbon dioxide and glucose.
7. Other constituents include:
    a. Aminoacids
    b. Sodium hyaluronate.
    c. Norepinephrine.
    d. Tissue plasminogen activator.
    e. Latent collagenase activity.

INTRAOCULAR PRESSURE

A normal IOP is one that does not cause glaucomatous optic nerve damage & field defects. It is that IOP at which an eye doesn't show any clinical evidence of optic nerve head or retinal nerve fibre layer changes .The normal IOP can be mentioned as 16 mmHg to 21 mmHg, however a single recording of IOP cannot give a clue to the patients normal range of IOP & nor can we label them as of having Glaucoma. The IOP varies in a given individual in a given time of day. (Diurnal variation)

Factors affecting IOP

- External pressure on the eye increases the IOP (Squeezing , etc)
- Acute and prolonged period of exercise decreases the aqueous humor production thus lowering the IOP.
- Elevated body temperature is associated with increase in aqueous production thus increasing the IOP
- Systemic acidosis decreases the aqueous humor production thus reducing IOP.

Effects of drugs

- Alcohol lowers IOP
- Heroin and Marijuana lowers IOP.
- LSD increases IOP
- Corticosteroids, topical or systemic increase IOP in steroid responders.
- Anti cholinergic drugs increase IOP by dilating the pupil and producing angle closure.
- Anesthetic agents usually decrease IOP by reducing the inflow. Ketamine is known to increase IOP
- Depolarizing muscle relaxants like succinyl choline and suxamethonium increase the intraocular pressure.

TONOMETERS & TONOMETRY

Tonometry is a technique with which the intraocular pressure of a given eye can be measured; this is performed by deforming the globe & correlating the force responsible for deformation to the pressure in the eye.

BASIC PRINCIPLES OF IOP MEASUREMENT

Eye is considered a uniform sphere filled with fluid under pressure. If the walls are thin enough, when a small force is applied the sphere pushes back with a force related to the internal pressure only. This is known as **Maklakow- Fick law or Imbert-Fick law**

Indentation tonometry [Schiotz] measures the corneal deformation or indentation in response to a standard pressure applied to the cornea using a small stylus.

Applanation tonometry measures the external pressure required to obtain a known quantity of corneal flattening [**Variable force** – Goldman tonometer] or the area flattened by a standard force for a size of plunger[**Constant force** – Maklakow tonometer]

Accuracy of the Imbert –Fick law depends on the following assumptions:

1. The corneal tissue is completely elastic and will offer no resistance to the applied force.
2. Tear film surface tension (which pulls the plunger) is negligible.
3. Change in global volume due to the indentation or applanation is very small and will not artificially increase the IOP.
4. The sclera, limbus and the cornea are homogenous and have similar elastic properties.

Goldman determined that for a normal thickness cornea [520 microns] and a 3.06 mm diameter plunger, the surface tension from the tear film and the elastic resistance of the cornea to applanation were well balanced and hence ignored.

OCULAR RIGIDITY (resistance to deformation of ocular coats) is an important factor for all tonometers, more so for indentation tonometers where an increase in IOP occurs due to application of heavy external pressure on the eye during measurement. There is artificial increase of IOP in patients with high ocular rigidity and artificial decrease of IOP in patients with low ocular rigidity.

CORNEAL RIGIDITY is the ability of the corneal tissue to resist change in shape in response to pressure. It plays an important role in the accuracy of all tonometers especially applanation tonometer. The mechanical rigidity of normal cornea is provided by the lamella of collagen fibrils (70% of the corneal dry wt and 90% of the thickness of the cornea).

Correction factors for central corneal thickness, ocular and corneal rigidity vary from clinically insignificant to highly significant values within a normal population distribution.

INDENTATION TONOMETERS

Schiotz tonometer deforms the cornea in the shape of a truncated cone.

DESCRIPTION:

It has a foot plate that rests on the cornea and a plunger which moves freely within the shaft in the foot plate. The frame weighs 11 grams & a permanently attached weight and the plunger weigh 5.5 grams. The degree to which it indents the cornea is indicated by the movement of needle on a scale. This reading is converted to IOP measurement in mm of Hg by using Friedenwald's table.

TECHNIQUE:

With patient in supine position fixing at a target, the examiner separates the eye lids. The tonometer foot plate is placed on the anesthetized cornea so that the plunger is free to move vertically. With tonometer properly positioned the examiner will observe the fine movements of the indicator needle on the scale in response to ocular pulsations. The scale reading should be noted as the average of the extremes. The 5.5 grams weight is initially used, but if scale reading is 4 or less additional weights is added to the plunger.

SOURCES OF ERROR

1. Ocular rigidity
2. Blood volume alterations
3. Corneal influences (steep or thick cornea give false high readings)
4. Moses effect (in very soft eyes corneal tissue can get impinged between the hole in the foot plate and the plunger pushing the plunger up artificially increasing the IOP)

Being cheap, portable and easy to use, it is of value in camp based settings.

VARIABLE FORCE APPLANATION TONOMETERS

Goldman applanation tonometer

Current gold standard variable force applanation tonometer. This slit-lamp mount tonometer measures IOP in accordance with Imbert-Fick law.

DESCRIPTION:

Mounted on a slit- lamp, the examiners view is directed through the centre of a plastic biprism. Two beam splitting prisms within the applanating unit optically convert the circular area of corneal contact into semicircles. The prisms are adjusted such that the inner margins of the semicircles overlap when 3.06 mm of the cornea in applanated. Coil spring and a series of levers are used to adjust the force of the biprism against the cornea.

TECHNIQUE:

The cornea is anesthetized and the tear film is stained with sodium fluorescein. With cornea and biprism illuminated with cobalt blue light, the biprism is brought into gentle contact with the apex of the cornea. The fluorescein semicircles are viewed through the biprism and the force against the cornea is adjusted till the inner edges overlap. The IOP is read directly form a scale on the tonometer housing (multiplied by 10).

SOURCES OF ERROR

1. Variations in IOP resulting from pulsatile blood flow.
2. Semicircles (wide menisci give false high reading).
3. Central corneal thickness (false high in thicker corneas)
4. Corneal curvature (increase by 1 mm Hg for every 3 diopter increase in corneal power and in cases of astigmatism)
5. Prolonged contact (corneal abrasion, decrease in IOP)
6. If not regularly calibrated readings may not be reliable

OTHER VARIABLE FORCE APPLANATION TONOMETERS

Perkins hand held applanation tonometer

The biprisms are illuminated by battery powered bulb & force on the prism is adjusted manually

Its **advantages** are:

Portable

No need for slit lamp bio microscope

Used in Operation Theater (for measuring IOP in children & Infants)

Draeger applanation tonometer

Similar to Perkins tonometer but has a different biprism and electronic motor to vary the force.

Mackay-Marg tonometer

Force required to keep the flat plate of the plunger flush with the surrounding sleeve against the pressure of corneal deformation in measured.

DESCRIPTION:

1.5 mm diameter plate surrounded by rubber sleeve. The force is electronically monitored and recorded on a paper strip.

TECHNIQUE:

The tip of the instrument touches the cornea. The tracing rises until the applanated area reaches 1.5 mm. This point represents the IOP + force required to bend the cornea. When 3 mm of cornea is flattened, the effect of corneal rigidity is transferred to the sleeve and the tracing records the IOP. Several readings should be averaged to compensate fluctuations due to ocular pulsation.

NEWER MODELS include:

Tono pen –This hand held model is portable & battery operated. It is based on the principles of the Mackay marg tonometer.

DESCRIPTION:

The tip consists of sensitive strain gauge, which gets activated when in contact with the cornea. Built in circuit senses the shape of the force curve & readings are recorded. Average of 5 to 10 readings are taken & displayed on the digital displayer. If force curve recorded is not in comparison with the standard, then that value is automatically discarded & new readings are taken.

TECHNIQUE:

Probe tip is gently applied on to the anesthetized cornea and tonometer automatically starts taking readings, an audible click sound indicates acceptable measurement, and a beep sound indicates completion of data collection.

It has been found that Tonopen underestimates IOP in low-pressure ranges, and over estimates IOP in High-pressure ranges.

However Tonopen readings are comparable with that of Goldman readings in eyes with silicon oil.

Pneumotonometer – The sensor is air pressure. It is useful in measuring the IOP in scarred & edematous corneas.

It can also be used for continuous intraocular pressure monitoring.

ADVANTAGES

1. More accurate than GAT for scarred, edematous and irregular cornea. (applanates a small area of the cornea takes corneal bending into account)
2. No loss of accuracy even if measured in peripheral cornea
3. Can be used in immediate post refractive surgery phase
4. Can be used in any patient position

Non contact tonometer

Introduced by Grolman in 1972. Fixed corneal area is applanated by a jet of air which increases in force linearly.

DESCRIPTION:

Mounted on a table. Has three subsystems:

1. Alignment system to optically align the patient's cornea.
2. Optoelectronic applanation monitoring system consisting of a transmitter (to direct collimated beam of light at the corneal apex), receiver, detector (which accepts only parallel coaxial rays reflected from the cornea).
3. Pneumatic system to generate a puff of air to flatten the cornea.

At the instant that the cornea is flattened, maximum reflected light is received and recorded as the peak intensity of light detected. The time from a reference point to maximum light detection is converted to IOP.

TECHNIQUE:

The patient fixes on the target. The examiner aligns the cornea by superimposing the reflection of the target from the patient's cornea on a stationary ring. On pressing the trigger, a puff of air flattens the cornea and IOP is displayed on the digital screen.

Time interval for a measurement is 1-3 ms. Three readings are taken and averaged for the IOP as the measurement is random with respect to cardiac cycle.

X-pert NCT – air puff automatically triggered when alignment is satisfied.

Pulsair – hand held NCT

ADVANTAGES:

1. Chances of abrasion and infection are eliminated.
2. Easy to use.
3. Screening by non medical personnel.

DISADVANTAGES:

1. Affected by irregular corneas and in eyes with poor fixation.
2. Corneal thickness produces larger variability in IOP than GAT.

CONSTANT FORCE APPLANATION TONOMETERS

Maklakov applanation tonometer

IOP is estimated by measuring the amount of cornea flattened by a known weight.

DESCRIPTION:

Dumbbell-shaped metal cylinder with flat endplates of polished glass on both ends with diameter of 10 mm. A set of four such instruments weighing 5, 7.5, 10 and 15 grams and a cross section wire handle to support the instrument on the cornea.

TECHNIQUE:

With patient in supine position and cornea anesthetized, a layer of dye is applied to either end plate. The instrument is allowed to rest vertically on the cornea for 1 second. A circular imprint of the end plate is produced on the cornea, which corresponds to the area of cornea flattened. The diameter of this is measured and the IOP read from a conversion table.

DISADVANTAGES:

1. Dependant on ocular rigidity and corneal irregularities.
2. Inaccuracies in reading due to corneal bending, capillary attraction and tear film surface tension.

CONTINUOUS IOP MONITORING DEVICES

1. Strain gauge placed in contact lenses to measure changes in meridional angle of corneoscleral junction. This may also be embedded in an encircling scleral band to measure distension of the globe.
2. Scleral applanating device attached to a passive radio telemetric transducer.
3. Contact lens tonometers.

HOME TONOMETERS

1. Self tonometer – using applanation principle
2. Measure of the duration of contact of a spring driven hammer with the eye.
3. Measure of the frequency of a vibrating probe with the cornea.
4. Patient seeing a" phosphene" or phantom image on mechanical pressure on the sclera

PASCAL DYNAMIC CONTOUR TONOMETER

It [DCT] a non-applanation contact tonometer based on the principle of contour matching. It uses a contact surface which matches the contour of the cornea and creates equilibrium between capillary force, rigidity force, appositional force and the force exercised on the cornea by IOP.

The pressure sensor integrated into the contoured surface is designated to provide IOP measurements. These are not affected by other forces acting on the corneal surface or by variations in corneal properties such as corneal thickness, radius of curvature or astigmatism.

DESCRIPTION and TECHNIQUE:

Mounted on a GAT stand at the slit lamp.

The tip of the tonometer is brought in contact with the cornea.

Correct positioning is indicated by an audible signal that changes in pitch with changes in pressure detected.

The tip generates an electric signal which is proportional to the IOP.

The signal is detected for a period of 5 seconds (5 to 10 heartbeats).

A numeric output of IOP and of ocular pulse amplitude [OPA] is furnished by the device.

ADVANTAGES:

1. Not affected by forces acting on the corneal surface
2. Not affected by variations in corneal radius of curvature or astigmatism.
3. Accurate assessment of IOP in thin corneas
4. No possibility of bias due to prior knowledge of IOP.
5. IOP for post LASIK patients.

DISADVANTAGES:

1. In thick corneas the IOP measurement with DCT is unreliable.
2. Expensive
3. Difficult to master the procedure.
4. Not preferable for less cooperative patients.

TONOPACH

A tonometer to measure the IOP and an ultrasonic pachymeter to measure central corneal thickness [CCT]. It is a portable, battery operated, handheld instrument. One measurement provides three readings: IOP, CCT and adjusted IOP

THE REICHERT OCULAR RESPONSE ANALYZER (ORA)

The Reichert Ocular Response Analyzer utilizes a "dynamic bi-directional applanation process" to measure both the biomechanical properties of the cornea and the IOP. The basic output is a Goldman-correlated applanation pressure measurement (IOPG) and a measure of corneal tissue properties called corneal hysteresis (CH), which is related to viscous damping in the corneal tissue.

The CH measurement also provides a basis for two additional parameters measured by the ORA: the corneal-compensated intraocular pressure (IOPCC) and the corneal resistance factor (CRF).

IOPCC is an IOP measurement designed to be less affected by corneal properties than is IOP measured by Goldman or NCT. IOPCC has essentially a zero correlation with CCT in normal eyes and stays relatively constant pre- versus post-LASIK.

CRF appears to be an indicator of the overall “resistance” of the cornea to applanation and is significantly correlated with CCT and GAT, but not with IOPCC.

The corneal hysteresis measurement is an indication of viscous damping in the cornea. In other words, it is related to the ability of the cornea to absorb and dissipate energy. Subjects whose corneas exhibit low CH can be thought of in simple terms as having a “soft” cornea.

DESCRIPTION and TECHNIQUE:

The ORA utilizes an air pulse to apply force to the cornea and an advanced electro-optical system to monitor the resultant corneal deformation. Alignment to the patient’s eye is fully automated.

A precisely metered, collimated air pulse causes the cornea to move inwards, past applanation, and into a slightly concave shape. Milliseconds after applanation, the air pump shuts off and the pressure declines in a smooth fashion. As the pressure decreases, the cornea begins to return to its normal configuration and once again passes through the applanated state. An applanation detection system monitors the cornea throughout the entire process and pressure values are recorded for the inward and outward applanation events.

Viscous damping in the cornea causes delays in the inward and outward applanation events, resulting in two different pressure values. The average of these two pressure values provides a repeatable, Goldman-correlated IOP value (IOPG). The difference between these two pressure values is corneal hysteresis (CH). The ability to measure this effect is the key to understanding the biomechanical properties of the cornea and their influence on the IOP measurement process.

ADVANTAGES:

1. Very short learning curve
2. Provides the additional metrics of dynamic biomedical properties of the cornea
3. Not affected by corneal thickness

MEASURING IOP IN SPECIAL CASES

IRREGULAR CORNEAS:

1. Pneumatic tonometer
2. Mackay-Marg tonometer
3. Tonopen

OVER A SOFT CONTACT LENS:

1. Pneumatic tonometer
2. Tonopen

IN GAS FILLED EYES:

1. Goldman applanation tonometer
2. Pneumatic tonometer
3. Tonopen

PART - II

AIM OF THE STUDY

To compare the IOP values obtained from Schiotz tonometer, Non-contact tonometer, Pascal's dynamic contour tonometer and Perkins hand held applanation tonometer and to evaluate their relationship with central corneal thickness if any.

DESIGN

Random cross sectional analytical study.

INCLUSION CRITERIA

1) Patients between the ages of 20 – 80 years
2) IOP between 7.0 – 50 mm of Hg by Perkins hand held applanation tonometer

EXCLUSION CRITERIA

1) Patients with corneal edema
2) Patients with corneal ulcer
3) Patients with corneal opacity
4) IOP <7 mm of Hg or >50 mm of Hg by Perkins hand held applanation tonometer
5) Patients with nystagmus

MATERIALS AND METHOD

Four hundred patients attending out patients department of Regional Institute of Ophthalmology, Government Ophthalmic Hospital, Chennai were screened and their intraocular pressure and central corneal thickness were measured.

Schiotz tonometer: The zero error of the instrument was taken by placing the footplate on the test block provided. Cornea was anaesthetized with 4% lignocaine (topical eye drops). In supine position, the patient was asked to fix at a target. The eye lids were separated and the tonometer foot plate was placed on the anesthetized cornea so that the plunger moved freely vertically. The scale reading was noted. The 5.5 grams weight was initially used, but if scale reading was 4 or less additional weights was added to the plunger. This reading was converted to IOP measurement in mm of Hg by using Friedenwald's table. Average of three readings was taken.

Non-contact tonometer: The patient was seated at the table top model of NCT and to fix on the target. The examiner aligned the cornea by superimposing the reflection of the target from the patient's cornea on a stationary ring. Air puff was automatically triggered when alignment was satisfied. Three readings were taken and averaged for the IOP as the measurement is random with respect to cardiac cycle.

Pascal's dynamic contour tonometer: This tonometer is mounted on a slit lamp. After seating the patient at the slit lamp, the tip of the tonometer was brought in contact with the cornea, such that the central marking on the tonometer tip coincided with the centre of the tear film on the cornea. Correct positioning was indicated by an audible signal that changes in pitch with changes in pressure detected. The position was maintained such that a continuous audible signal was heard for at least 5 seconds. A numeric output of IOP and of ocular pulse amplitude [OPA] was furnished by the device on the electronic screen. Readings with quality indicated by "Q1" or "Q2" were taken for the study.

Perkins hand held applanation tonometer: The cornea was anesthetized and the tear film stained with sodium fluorescein. With cornea and biprism illuminated with cobalt blue light, the biprism was brought into gentle contact with the apex of the cornea. The fluorescein semicircles were viewed through the biprism and the force against the cornea adjusted till the inner edges overlap. The IOP was read directly from a scale on the tonometer and multiplied by 10.

Pachymetry: With the patient seated and fixing on a distant target, the pachymetry probe was placed on the anaesthetized cornea. Three consecutive readings were taken and averaged to get the central corneal thickness.

The examiner measuring the IOP by one method was blinded to the IOP measurements obtained by the other tonometers as well as the pachymetry value.

Results were analyzed by a neutral statistician.

RESULTS

Perkin's hand held applanation tonometer was taken as the gold standard technique and the other methods were compared to it.

All the three techniques showed good agreement between the readings, with Pascal's DCT agreeing at 0.75 intra class correlation (ICC), NCT at 0.72 ICC and Schiotz indentation tonometer at 0.66 ICC.

OVERALL CORRELATION

	PASCAL	**NCT**	**SCHIOTZ**
ICC	0.75	0.72	0.66

Comparing correlation at different age groups:

Pascal had the highest correlation in all age groups, with maximum correlation at <40 years group.

All the methods had better correlation at <40 years age group.

CORRELATION IN DIFFERENT AGE GROUPS

	PASCAL	**NCT**	**SCHIOTZ**
< 40	0.8	0.75	0.73
41 - 60	0.75	0.72	0.66
> 61	0.72	0.71	0.63

ICC was higher among diabetics than non – diabetics, and highest for Pascal DCT as compared to the other two methods.

CORRELATION IN DAIBETICS AND NON DIABETICS

	PASCAL	**NCT**	**SCHIOTZ**
DM	0.91	0.85	0.8
No DM	0.65	0.6	0.57

Non hypertensives correlated better with the gold standard technique, with ICC for Pascal DCT being the highest.

CORRELATION IN HYPERTENSIVES AND NON HYPERTENSIVES

	PASCAL	**NCT**	**SCHIOTZ**
HT	0.56	0.49	0.44
No HT	0.79	0.76	0.69

Correlation with all the three methods with the gold standard was higher in males than in females. This may probably be due to more males in the study.

CORRELATION IN MALES AND FEMALES

	PASCAL	**NCT**	**SCHIOTZ**
MALE	0.83	0.81	0.77
FEMALE	0.68	0.65	0.56

Maximum number of patients had central corneal thickness of less than 520 microns

CCT	< 520	521 - 540	> 541
No. of patients	316	214	270

The ICC was maximum in patients with central corneal thickness 521 - 540 microns.

CORRELATION IN DIFFERENT CCT RANGES

	PASCAL	NCT	SCHIOTZ
< 520	0.76	0.66	0.56
521 - 540	0.86	0.88	0.84
> 540	0.56	0.49	0.46

The correlation was more in IOP ranges greater than 22 mm of Hg.

CORRELATION IN DIFFERENT IOP RANGES

	< 21mm Hg	**> 22 mm Hg**
PASCAL	0.47	0.77
NCT	0.41	0.8
SCHIOTZ	0.39	0.82

Intra ocular pressure difference was not statistically significant in the different age groups. Only the Central corneal thickness showed age related increase, and this age related change was more significant in the <40 and >40 years age group as compared to the 40-40 and >60 years age group.

There was however no statistically significant difference in the CCT values in patients with diabetes, hypertension. There was also no gender difference in the CCT values.

CONCLUSION

Comparing correlation at different age groups:

Pascal had the highest correlation in all age groups, with maximum correlation at <40 years group.

All the methods had better correlation at <40 years age group.

Intra class correlation was higher among diabetics than non – diabetics, and highest for Pascal DCT as compared to the other two methods.

Non hypertensives correlated better with the gold standard technique, with intra class correlation for Pascal DCT being the highest. This could be due to higher number of hypertensives in the study.

Correlation with all the three methods with the gold standard was higher in males than in females. This may probably be due to more males in the study.

The intra class correlation was maximum in patients with central corneal thickness 520 - 540 microns. This is probably due to more number of patients in this group.

Intra ocular pressure difference was not found to be statistically significant in the different age groups.

However, the central corneal thickness showed age related increase. This age related change was more significant on comparing the <40 and 40 – 60 years age group as compared to the 40-60 and >60 years age group.

There was however no statistically significant difference in the central corneal thickness values in patients with diabetes, hypertension. There was also no gender difference in the central corneal thickness values.

In conclusion:

All the tonometers showed significant correlation with the gold standard technique (Perkin's applanation tonometer), over a range of intra ocular pressures, between 20 to 80 years, in diabetics and hypertensives and also in patients with different CCT values.

But Pascal's DCT showed higher correlation with the gold standard as compared to NCT or Schiotz indentation tonometer.

DISCUSSION:

With control of intra ocular pressure being one of the most important targets of anti glaucoma medications, it is important to measure the intra ocular pressure precisely.

Numerous tonometers are now available in the market, each with their own distinct advantages and disadvantages. It therefore becomes essential to determine the reliability of these tonometers and also to determine their usefulness in special situations.

Perkins hand held applanation tonometer

This is a hand held model of applanation tonometer. It has the advantage that it can be used in infants and children during examination under anesthesia and also in patients who are unable to sit at the slit lamp.

The accuracy of the readings however depends on the amount fluorescein in the cul de sac. Thick mires give false high readings and very thin mires give false low readings. Improper vertical alignment of the mires also gives false high values. Inaccurate values are also obtained in irregular corneas.

This instrument is calibrated for mean central corneal thickness between 520 – 540 microns. It has been found that there is an average error of 2.57 mm of Hg for every 30 microns deviation in central corneal thickness in the Indian population (AIOC proceedings 2005).

Pascal's dynamic contour tonometer

Its contact surface matches the contour of the cornea and thereby creates equilibrium between capillary force, rigidity force, appositional force and the force exercised on the cornea by IOP. The pressure sensor integrated into the contoured surface, provide IOP measurements. When it touches the cornea it allows the cornea to assume its natural shape when pressure on both sides is equal and distortion of the cornea is minimal. These measurements are not affected by other forces acting on the corneal surface or by variations in corneal properties such as corneal thickness, radius of curvature or astigmatism.

It is however a slit lamp mounted model and cannot be used in uncooperative patients. It can also not be used in patients with nystagmus as a continuous beep for the required 5 seconds is difficult to achieve in such patients. Though the values are not very reliable in thick corneas, reliable intra ocular pressure measurements are obtained in post LASIK patients who have thin corneas and are likely to have false low readings by applanation tonometers. A recent study showed that while DCT was reliable in thin corneas, applanation tonometer is more reliable in corneas with high curvatures. (Ophthalmology AAO 2007)

Non-contact tonometer

It has the obvious advantage of being easy to use by non medical personnel. Also chances of abrasion and infection are eliminated. It can be used for mass screening. However many studies have found that NCT over estimates the intra ocular pressure. Also NCT cannot be used in patient with poor fixation and those with corneal edema.

Schiotz tonometer

Schiotz tonometer, being cheap and easily portable gained immense popularity in the past. It still has limited value in camp settings. However the results of Schiotz tonometry are known to be affected by factors like scleral rigidity, compressibility of the vascular content of the eye and the ease with which the fluid is expressed through the drainage channels. In eyes with soft corneal tissues, “Moses effect” can cause a false high reading.

Comparing correlation at different age groups:

Pascal had the highest correlation in all age groups, with maximum correlation at <40 years group.

All the methods had better correlation at <40 years age group.

This is probably due to the increase in central corneal thickness with age. Age-related change in corneal resistance to applanation has also been documented. This could have also affected the IOP values in the >40 years age group.

Intra class correlation was higher among diabetics than non – diabetics, and highest for Pascal DCT as compared to the other two methods. Increase in central corneal thickness in diabetics has been documented. Maximum patients in this study had central corneal thickness < 520 microns. As applanation tonometer is calibrated for central corneal thickness between 520 – 540 microns, this could be an explanation for the observation that ICC is higher in diabetics.

Non hypertensives correlated better with the gold standard technique, with intra class correlation for Pascal DCT being the highest. This could be due to higher number of non hypertensives in the study.

Correlation with all the three methods with the gold standard was higher in males than in females. This may probably be due to more males in the study.

The intra class correlation was maximum in patients with central corneal thickness 520 - 540 microns. Applanation tonometer is calibrated for central corneal thickness between 520 – 540 microns. So it is possible that most accurate values are obtained at this central corneal thickness range.

Intra ocular pressure difference was not found to be statistically significant in the different age groups.

However, the **central corneal thickness showed age related increase**. This age related change was more significant on comparing the <40 and 40 – 60 years age group as compared to the 40-60 and >60 years age group. This finding correlates with other studies which have shown age related increase in corneal thickness as well as corneal rigidity.

There was however no statistically significant difference in the central corneal thickness values in patients with diabetes, hypertension. There was also no gender difference in the central corneal thickness values.

PART - III

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LIST OF ABBREVIATIONS USED

IOP – Intra Ocular Pressure

LSD – Lysergic Diethylamide

mm – millimeters

GAT – Goldman Applanation Tonometer

NCT – Non Contact Tonometer

DCT – Dynamic Contour Tonometer

OPA – Ocular Pulse Amplitude

LASIK – LaserAssisted In Situ Keratomeleusis

CCT – Central Corneal Thickness

ORA – Ocular Response Analyser

IOPG – Goldman-correlated applanation pressure measurement

CH – Corneal Hysteresis

IOPC – Corneal-compensated intraocular pressure

CRF – Corneal resistance factor

ICC – Intra class correlation

AIOC – All India Ophthalmic Conference

AAO – American Academy of Ophthalmology

PROFORMA

SL.NO.:

NAME:

AGE:

GENDER:

DIABETES: **PRESENT / ABSENT**

HYPERTENSION: **PRESENT / ABSENT**

CENTRAL CORNEAL THICKNESS:
RIGHT EYE
LEFT EYE

IOP BY PERKINS APPLANATION TONOMETER:
RIGHT EYE
LEFT EYE

IOP BY PASCALS DYNAMIC CONTOUR TONOMETER:
RIGHT EYE
LEFT EYE

IOP BY NON CONTACT TONOMETER:
RIGHT EYE
LEFT EYE

IOP BY SCHIOTZ TONOMETER:
RIGHT EYE
LEFT EYE

MASTER CHART

Sl.No.	Name	age	gender	eye	DM	HT	CCT	method-1	method-2	method-3	method-4
1	Munusamy	45	1	1	2	2	540	18	19	23	20.6
2	Munusamy	45	1	2	2	2	539	20	20	22	20.6
3	Chinnatha	32	2	1	2	2	530	20	21.4	20	17.3
4	Chinnatha	32	2	2	2	2	525	14	20.8	21	17.3
5	Veeran	65	1	1	2	2	370	12	13	9	14.6
6	Veeran	65	1	2	2	2	375	22	27	17	24.6
7	Subramani	49	1	1	2	2	490	14	13.5	12	12.2
8	Subramani	49	1	2	2	2	501	14	14.2	12	12.2
9	Joseph	42	1	1	2	2	482	18	18.4	15	14.6
10	Joseph	42	1	2	2	2	490	18	17.7	13	14.6
11	Balakondaiyah	48	1	1	2	1	513	12	19.5	15	17.3
12	Balakondaiyah	48	1	2	2	1	526	14	17.6	18	17.3
13	Elumalai	43	1	1	2	2	481	8	19.1	16	17.3
14	Elumalai	43	1	2	2	2	500	10	17.9	15	17.3
15	Chinnaya	45	1	1	2	2	563	26	24.9	22	17.3
16	Chinnaya	45	1	2	2	2	550	20	23.2	21	17.3
17	Yusuf	53	1	1	2	2	526	20	21.1	22	20.6
18	Yusuf	53	1	2	2	2	521	10	14.4	13	14.6
19	Govindan	57	1	1	1	2	478	18	24	16	17.3
20	Govindan	57	1	2	1	2	531	10	14.7	14	17.3
21	Rajan	42	1	1	2	2	495	8	12.9	11	10.2
22	Rajan	42	1	2	2	2	490	8	13.9	12	12.2
23	Saroja	75	2	1	2	2	485	26	28.8	25	29
24	Saroja	75	2	2	2	2	474	10	13	7	17.3
25	Govindasamy	34	1	1	2	2	524	26	25.1	29	29
26	Govindasamy	34	1	2	2	2	535	34	33.6	35	34.5
27	Venkatesan	28	1	1	2	2	566	12	13	12	12.2
28	Venkatesan	28	1	2	2	2	566	10	13.5	14	12.2
29	Moorthy	60	1	1	2	2	495	10	13.1	10	10.2
30	Moorthy	60	1	2	2	2	485	6	9	6	10.2
31	Annatha	50	2	1	1	2	532	14	17.7	14	17.3
32	Annatha	50	2	2	1	2	530	14	14.3	14	24.4
33	Saroja	42	2	1	2	2	550	10	11.4	10	12.2
34	Saroja	42	2	2	2	2	546	12	10.1	12	12.2
35	Panchali	55	2	1	1	2	495	12	12.6	9	10.2
36	Panchali	55	2	2	1	2	516	12	12.6	11	10.2
37	Thirumal	60	1	1	2	2	490	10	21.6	13	14.6
38	Thirumal	60	1	2	2	2	530	8	9.8	7	10.2
39	Govindammal	61	2	1	2	1	510	16	13.8	12	20.6
40	Govindammal	61	2	2	2	1	505	14	17.4	14	14.6
41	Dilli Bai	65	2	1	2	2	525	12	13.7	11	14.6
42	Dilli Bai	65	2	2	2	2	525	14	13.8	12	14.6
43	Noorbibi	65	2	1	2	2	444	14	14.6	12	8.5
44	Noorbibi	65	2	2	2	2	468	12	15.4	10	10.2
45	Kamala	60	2	1	2	2	502	8	14.8	10	10.2
46	Kamala	60	2	2	2	2	500	16	17.2	11	18.9
47	Anandi	45	2	1	2	2	542	12	14.9	15	12.2

48	Anandi	45	2	2	2	2	556	14	12.4	13	12.2
49	Seetha	62	2	1	2	1	576	12	18.7	13	14.6
50	Seetha	62	2	2	2	1	568	10	17.4	11	14.6
51	Kanthammal	70	2	1	2	2	424	12	14.3	9	7.1
52	Kanthammal	70	2	2	2	2	431	14	14.4	10	10.2
53	Mumtaz	55	2	1	2	2	543	14	16.5	12	14.6
54	Mumtaz	55	2	2	2	2	547	16	16.1	13	14.6
55	Sethu	60	2	1	1	2	554	12	15.2	10	17.3
56	Sethu	60	2	2	1	2	552	14	16.5	15	17.3
57	Kalyani	60	2	1	2	1	486	10	12	9	14.6
58	Kalyani	60	2	2	2	1	476	12	15.9	12	17.3
59	Anjalai	65	2	1	2	1	478	8	10.6	3	7.1
60	Anjalai	65	2	2	2	1	472	10	10.8	6	7.1
61	Suseela	65	2	1	1	2	516	16	16.8	13	14.6
62	Suseela	65	2	2	1	2	534	12	12.7	13	17.3
63	Kurinji	60	2	1	1	1	502	10	16.8	15	14.6
64	Kurinji	60	2	2	1	1	496	10	17.3	14	14.6
65	Haseena	42	2	1	1	2	504	16	17.8	13	10.2
66	Haseena	42	2	2	1	2	511	18	19.6	15	14.6
67	Nagammal	70	2	1	2	2	498	18	19.6	13	17.3
68	Nagammal	70	2	2	2	2	498	16	17.8	14	17.3
69	Kondammal	60	2	1	2	1	493	8	16.3	14	17.3
70	Kondammal	60	2	2	2	1	516	12	16.1	14	17.3
71	Padma	67	2	1	2	1	543	10	16.8	10	12.2
72	Padma	67	2	2	2	1	564	12	22.6	18	12.2
73	Kooviammal	80	2	1	2	2	569	12	12.3	9	12.2
74	Kooviammal	80	2	2	2	2	540	8	16.3	10	17.3
75	Senthamarai	42	2	1	2	2	541	16	17.9	18	12.2
76	Senthamarai	42	2	2	2	2	513	14	17.3	15	14.6
77	Chinnaponnu	80	2	1	2	2	490	12	8.7	15	17.3
78	Chinnaponnu	80	2	2	2	2	463	14	14.3	13	14.6
79	Sarojammal	75	2	1	2	2	553	10	13.1	10	10.2
80	Sarojammal	75	2	2	2	2	490	8	15.3	11	10.2
81	Kaveri	55	2	1	2	2	531	14	15.6	12	14.6
82	Kaveri	55	2	2	2	2	533	12	15.3	12	14.6
83	Annammal	70	2	1	2	2	541	10	12.9	11	12.2
84	Annammal	70	2	2	2	2	555	12	14.9	13	12.2
85	Chakkarai	60	2	1	2	1	544	8	20.6	19	17.3
86	Chakkarai	60	2	2	2	1	536	12	21.1	19	17.3
87	Kamalam	45	2	1	2	2	432	12	15.4	8	14.6
88	Kamalam	45	2	2	2	2	430	12	14.9	10	12.2
89	Pichai	53	1	1	2	2	541	16	20.6	19	17.3
90	Pichai	53	1	2	2	2	532	16	19.6	17	14.6
91	Shiva	73	1	1	2	2	360	8	10.9	12	8.5
92	Shiva	73	1	2	2	2	470	10	15.1	10	14.6
93	Isac	62	1	1	2	2	530	8	11.6	8	10.2
94	Isac	62	1	2	2	2	534	6	17.8	14	10.2
95	Perumal	55	1	1	2	2	511	10	10.8	10	14.6
96	Perumal	55	1	2	2	2	512	26	42.2	33	29
97	Rudran	47	1	1	1	2	521	48	48	55	42.1
98	Rudran	47	1	2	1	2	504	10	18	19	14.6
99	Selvam	54	1	1	2	2	620	10	8.2	11	10.2

100	Selvam	54	1	2	2	2	564	10	12.1	16	10.2
101	Veeran	70	1	1	2	2	572	14	12.4	12	8.5
102	Veeran	70	1	2	2	2	576	8	11.7	12	10.2
103	Ahalya	35	2	1	2	2	558	12	15.8	14	17.3
104	Ahalya	35	2	2	2	2	560	10	14	13	14.6
105	Jayam	45	2	1	1	2	560	18	15.1	19	14.6
106	Jayam	45	2	2	1	2	572	18	16.4	19	14.6
107	Navaneetham	45	2	1	2	2	542	8	8.2	10	8.5
108	Navaneetham	45	2	2	2	2	537	10	12.5	16	14.6
109	Kumar	40	1	1	2	2	490	12	16.5	11	12.2
110	Kumar	40	1	2	2	2	504	10	15.1	11	12.2
111	Padmavathi	50	2	1	1	1	532	14	18.4	14	14.6
112	Padmavathi	50	2	2	1	1	542	10	17.2	13	14.6
113	Velu	51	1	1	2	2	542	12	12.1	8	10.2
114	Velu	51	1	2	2	2	530	14	15.7	13	12.2
115	Thirumoorthy	60	1	1	2	2	610	16	19.4	20	14.6
116	Thirumoorthy	60	1	2	2	2	604	18	18.5	21	17.3
117	Thirumalai	60	1	1	1	2	528	10	14.3	10	12.2
118	Thirumalai	60	1	2	1	2	551	10	13.9	12	10.2
119	Kuttiammal	58	2	1	1	2	492	12	16.1	10	8.5
120	Kuttiammal	58	2	2	1	2	507	14	15	13	14.6
121	Venkatasamy	55	1	1	2	2	535	12	15.7	10	17.3
122	Venkatasamy	55	1	2	2	2	547	20	23.3	15	29
123	Raju	44	1	1	2	2	525	12	17.2	13	12.2
124	Raju	44	1	2	2	2	532	12	16.4	14	12.2
125	Geetha	20	2	1	2	2	646	14	15.4	14	14.6
126	Geetha	20	2	2	2	2	550	16	13	11	12.2
127	Padma	52	2	1	2	2	528	10	17.3	12	14.6
128	Padma	52	2	2	2	2	527	12	18.2	16	17.3
129	Shabnam	60	2	1	2	2	468	12	17.3	11	17.3
130	Shabnam	60	2	2	2	2	474	12	13.5	11	17.3
131	Mary	55	2	1	2	2	502	10	12.7	8	12.2
132	Mary	55	2	2	2	2	507	14	14.5	12	12.2
133	Vasantha	47	2	1	2	2	472	18	17.4	13	14.6
134	Vasantha	47	2	2	2	2	470	14	15.8	12	14.6
135	Baskaran	68	1	1	1	2	580	22	23.1	24	24.2
136	Baskaran	68	1	2	1	2	602	16	16.6	18	14.6
137	Saraswathy	65	2	1	2	2	471	6	13.3	8	10.2
138	Saraswathy	65	2	2	2	2	471	6	11.6	7	10.2
139	Jaya	57	2	1	2	2	542	16	15.7	12	10.2
140	Jaya	57	2	2	2	2	537	16	14.6	13	17.3
141	Chintamani	70	1	1	2	2	536	24	24.7	22	17.3
142	Chintamani	70	1	2	2	2	536	24	22.8	25	24.4
143	Beevi	49	2	1	2	2	516	12	13.6	14	17.3
144	Beevi	49	2	2	2	2	508	10	12.3	14	17.3
145	Annapoorni	70	2	1	2	2	501	16	16.7	11	10.2
146	Annapoorni	70	2	2	2	2	476	16	17.5	11	10.2
147	Kamakshi	55	2	1	1	1	506	26	23	13	17.3
148	Kamakshi	55	2	2	1	1	518	22	18.7	16	17.3
149	Sarada	60	2	1	1	2	586	22	21	16	17.3
150	Sarada	60	2	2	1	2	580	14	15.8	17	17.3
151	Yellamalai	78	1	1	2	2	512	22	28.7	20	17.3

152	Yellamalai	78	1	2	2	2	510	12	13.7	10	12.2
153	Saroja	35	2	1	2	2	540	14	16.4	14	17.3
154	Saroja	35	2	2	2	2	548	14	14.1	13	17.3
155	Hamsa	40	2	1	2	2	546	18	17.4	15	14.6
156	Hamsa	40	2	2	2	2	540	16	16.8	14	14.6
157	Saraswathy	51	2	1	2	1	543	2	19.1	17	14.6
158	Saraswathy	51	2	2	2	1	540	14	16.3	15	14.6
159	Durga	39	2	1	2	2	545	22	15	15	14.6
160	Durga	39	2	2	2	2	550	16	15.4	15	14.6
161	Govindammal	60	2	1	2	2	464	12	13	9	10.2
162	Govindammal	60	2	2	2	2	570	22	26.4	11	12.2
163	Karupayi	71	2	1	2	2	525	18	19.1	14	17.3
164	Karupayi	71	2	2	2	2	498	20	23.1	14	17.3
165	Valli	56	2	1	1	2	474	12	14.2	11	17.3
166	Valli	56	2	2	1	2	521	14	13.5	10	17.3
167	Durai	54	1	1	2	2	482	8	16.8	10	10.2
168	Durai	54	1	2	2	2	487	8	15.1	13	11.4
169	Kamban	61	1	1	2	2	480	10	14.3	8	17.3
170	Kamban	61	1	2	2	2	532	12	15.3	10	17.3
171	Chinnasamy	60	1	1	2	2	520	16	16.1	11	12.2
172	Chinnasamy	60	1	2	2	2	511	14	15	13	12.2
173	Duraisamy	53	1	1	2	2	565	12	12.6	15	14.6
174	Duraisamy	53	1	2	2	2	569	8	11.8	14	14.6
175	Vellai	40	1	1	2	2	503	10	11.1	8	14.6
176	Vellai	40	1	2	2	2	493	6	11.9	10	12.2
177	Krishnasamy	47	1	1	2	2	526	14	13.1	10	17.3
178	Krishnasamy	47	1	2	2	2	531	12	14.1	9	17.3
179	Rajendran	61	1	1	2	2	532	12	15.1	10	12.2
180	Rajendran	61	1	2	2	2	509	10	12.2	12	12.2
181	Muhamed	65	1	1	2	2	527	14	17.9	11	14.6
182	Muhamed	65	1	2	2	2	550	8	17.1	11	14.6
183	Babu	60	1	1	2	2	603	10	12	17	7.1
184	Babu	60	1	2	2	2	610	12	10.2	18	17.3
185	Suresh	26	1	1	2	2	603	12	15.1	11	12.2
186	Suresh	26	1	2	2	2	612	10	15.2	9	14.6
187	Yesu	37	1	1	2	2	593	18	19.1	15	17.3
188	Yesu	37	1	2	2	2	603	20	23.1	10	17.3
189	Durairaj	47	1	1	2	2	560	12	11.1	14	14.6
190	Durairaj	47	1	2	2	2	556	12	11.8	13	14.6
191	Basha	51	1	1	2	2	529	10	15.7	12	17.3
192	Basha	51	1	2	2	2	497	12	12.1	10	17.3
193	Chellammal	60	2	1	2	2	466	8	14.1	7	12.2
194	Chellammal	60	2	2	2	2	458	10	12.2	9	12.2
195	Ambika	67	2	1	2	2	531	14	18.2	12	14.6
196	Ambika	67	2	2	2	2	545	10	15.7	12	14.6
197	Mary	70	2	1	2	2	624	8	16.3	12	12.2
198	Mary	70	2	2	2	2	598	10	20.1	16	12.2
199	Gowri	72	2	1	2	2	612	10	13.2	17	12.2
200	Gowri	72	2	2	2	2	581	16	16.5	17	14.6
201	Saroja	45	2	1	1	2	524	14	14.8	14	14.6
202	Saroja	45	2	2	1	2	521	16	18.4	18	17.3
203	Kamakshi	55	2	1	2	2	510	12	13.1	12	17.3

204	Kamakshi	55	2	2	2	2	542	16	15.2	14	17.3
205	Fathima	45	2	1	2	2	552	16	18.2	12	17.3
206	Fathima	45	2	2	2	2	538	18	15.3	12	17.3
207	Jaya	65	2	1	1	1	520	18	19.5	17	14.6
208	Jaya	65	2	2	1	1	504	18	19.4	17	14.6
209	Saraswathy	30	2	1	2	2	524	16	17.9	15	17.3
210	Saraswathy	30	2	2	2	2	540	16	14.8	14	17.3
211	Begum	65	2	1	2	2	504	14	14.3	13	14.6
212	Begum	65	2	2	2	2	519	14	15.2	14	14.6
213	Ponnammal	45	2	1	2	2	552	8	16.1	13	14.6
214	Ponnammal	45	2	2	2	2	564	8	16.4	13	14.6
215	Sarada	65	2	1	2	2	551	12	12.1	13	14.6
216	Sarada	65	2	2	2	2	596	14	12.6	14	12.2
217	Yellammal	65	2	1	1	2	525	18	15.5	13	14.6
218	Yellammal	65	2	2	1	2	527	20	20.7	17	17.3
219	Palani	54	1	1	2	2	540	16	14.6	17	14.6
220	Palani	54	1	2	2	2	515	14	15.9	15	17.3
221	Swaminathan	67	1	1	2	2	497	12	13	15	17.3
222	Swaminathan	67	1	2	2	2	467	14	15.5	13	14.6
223	Muniyandi	54	1	1	2	2	550	10	13	10	10.2
224	Muniyandi	54	1	2	2	2	495	12	15	11	10.2
225	Nagaraj	57	1	1	2	2	531	14	20.7	12	14.6
226	Nagaraj	57	1	2	2	2	531	12	21.2	12	10.2
227	Geetha	60	2	1	2	2	540	10	15.4	11	12.2
228	Geetha	60	2	2	2	2	545	10	14.8	12	14.6
229	Selvi	58	2	1	2	1	545	8	20.6	18	17.3
230	Selvi	58	2	2	2	1	535	12	19.7	19	17.3
231	Sarojammal	48	2	1	2	2	432	12	10.9	8	14.6
232	Sarojammal	48	2	2	2	2	430	14	15.1	10	12.2
233	Roja	52	2	1	2	2	540	16	11.9	19	17.3
234	Roja	52	2	2	2	2	530	16	17.5	16	14.6
235	Sudha	49	2	1	2	2	460	8	10.9	12	10.2
236	Sudha	49	2	2	2	2	470	10	12.2	11	12.2
237	Bhuvana	39	2	1	2	2	530	8	13.1	8	14.6
238	Bhuvana	39	2	2	2	2	535	6	11.7	15	12.2
239	Saroja	47	2	1	2	2	501	10	10.7	10	14.6
240	Saroja	47	2	2	2	2	502	26	42.2	33	29
241	Kamakshi	45	2	1	1	2	521	48	48	56	42.1
242	Kamakshi	45	2	2	1	2	507	10	18.1	20	14.6
243	Ponni	56	2	1	2	2	620	10	8.2	11	10.2
244	Ponni	56	2	2	2	2	564	12	12.1	15	12.2
245	Andiappan	48	1	1	2	2	570	14	12.4	12	8.5
246	Andiappan	48	1	2	2	2	575	8	11.5	11	10.2
247	Chuppan	65	1	1	2	2	555	12	15.7	14	17.3
248	Chuppan	65	1	2	2	2	560	10	14.3	14	14.6
249	Karpagam	62	2	1	1	2	560	18	15.1	19	14.6
250	Karpagam	62	2	2	1	2	570	18	16.5	18	14.6
251	Vishnu	57	1	1	2	2	540	8	8.3	10	12.2
252	Vishnu	57	1	2	2	2	535	10	12.5	15	14.6
253	Boomi	58	2	1	2	2	490	12	16.5	10	12.2
254	Boomi	58	2	2	2	2	501	10	15	11	12.2
255	Mariammal	45	2	1	1	1	530	14	18.1	14	14.6

256	Mariammal	45	2	2	1	1	540	10	17.7	13	14.6
257	Sarada	53	2	1	2	2	517	22	22.8	20	17.3
258	Sarada	53	2	2	2	2	520	20	19	16	17.3
259	Rasathi	60	2	1	1	1	565	32	30.5	33	24.4
260	Rasathi	60	2	2	1	1	590	30	33.7	33	24.4
261	Bhuvaneswari	45	2	1	2	2	530	16	20.5	17	17.3
262	Bhuvaneswari	45	2	2	2	2	540	16	17.5	15	12.2
263	Pinky	35	2	1	2	2	500	10	14.9	11	14.6
264	Pinky	35	2	2	2	2	495	10	11.4	9	12.2
265	Unnamalai	52	2	1	2	2	604	8	17.4	14	12.2
266	Unnamalai	52	2	2	2	2	598	10	19.3	15	17.3
267	Nagammal	66	2	1	2	2	504	22	24.9	19	17.3
268	Nagammal	66	2	2	2	2	521	20	21.3	14	17.3
269	Susheela	50	2	1	2	2	574	12	14.3	15	17.3
270	Susheela	50	2	2	2	2	580	16	15.9	16	12.2
271	Kamalammal	47	2	1	1	2	481	22	22.2	16	20.6
272	Kamalammal	47	2	2	1	2	508	18	19.7	15	20.6
273	Chittan	55	1	1	2	2	554	16	14	13	10.2
274	Chittan	55	1	2	2	2	539	12	14	12	14.6
275	Muniammal	45	2	1	2	2	582	16	16.2	13	14.6
276	Muniammal	45	2	2	2	2	584	12	12.3	12	14.6
277	Karpagam	75	2	1	2	2	604	10	11.9	6	12.2
278	Karpagam	75	2	2	2	2	554	8	13.5	8	12.2
279	Ganesan	63	1	1	2	2	596	16	18.8	15	17.3
280	Ganesan	63	1	2	2	2	598	12	22.7	27	17.3
281	Leela	50	2	1	1	2	533	16	16.6	15	17.3
282	Leela	50	2	2	1	2	530	16	15.3	13	17.3
283	Shakuntala	58	2	1	2	2	512	12	15.8	10	12.2
284	Shakuntala	58	2	2	2	2	534	20	20.7	20	17.2
285	Parvathi	65	2	1	2	2	570	20	15.8	15	14.6
286	Parvathi	65	2	2	2	2	575	18	14.2	16	17.3
287	Vanathi	57	2	1	1	2	488	14	15.5	11	14.6
288	Vanathi	57	2	2	1	2	498	12	13.7	9	14.6
289	Sakkubai	67	2	1	1	2	527	12	15.6	8	8.5
290	Sakkubai	67	2	2	1	2	477	14	13.5	7	8.5
291	Velan	33	1	1	2	2	508	14	18	13	17.3
292	Velan	33	1	2	2	2	510	14	16.2	17	17.3
293	Rama	50	2	1	2	2	536	14	18.9	13	14.6
294	Rama	50	2	2	2	2	540	12	17.8	14	14.6
295	Pichai	59	1	1	2	2	556	12	18.1	14	14.6
296	Pichai	59	1	2	2	2	534	14	21.7	18	17.3
297	Susheela	60	2	1	2	2	468	12	17.3	11	17.3
298	Susheela	60	2	2	2	2	474	12	13.5	11	17.3
299	Karpagam	55	2	1	2	2	502	10	12.7	8	12.2
300	Karpagam	55	2	2	2	2	507	14	14.5	12	12.2
301	Nalini	47	2	1	2	2	472	18	17.4	13	14.6
302	Nalini	47	2	2	2	2	470	14	15.8	12	14.6
303	Kannan	68	1	1	1	2	580	22	23.1	24	24.2
304	Kannan	68	1	2	1	2	602	16	16.6	18	14.6
305	Sheela	65	2	1	2	2	471	6	13.3	8	10.2
306	Sheela	65	2	2	2	2	471	6	11.6	7	10.2
307	Muniammal	57	2	1	2	2	542	16	15.7	12	10.2

308	Muniammal	57	2	2	2	2	537	16	14.6	13	17.3
309	Kandappan	70	1	1	2	2	536	24	24.7	22	17.3
310	Kandappan	70	1	2	2	2	536	24	22.8	25	24.4
311	Rukmani	49	2	1	2	2	516	12	13.6	14	17.3
312	Rukmani	49	2	2	2	2	508	10	12.3	14	17.3
313	Govindammal	70	2	1	2	2	501	16	16.7	11	10.2
314	Govindammal	70	2	2	2	2	476	16	17.5	11	10.2
315	Selvi	55	2	1	1	1	506	26	23	13	17.3
316	Selvi	55	2	2	1	1	518	22	18.7	16	17.3
317	Nagammal	60	2	1	1	2	586	22	21	16	17.3
318	Nagammal	60	2	2	1	2	586	14	15.8	17	17.3
319	Raman	78	1	1	2	2	519	22	28.7	20	17.3
320	Raman	78	1	2	2	2	510	12	13.7	10	12.2
321	Lalitha	35	2	1	2	2	540	14	16.4	14	17.3
322	Lalitha	35	2	2	2	2	558	14	14.1	13	17.3
323	Sarada	40	2	1	2	2	566	18	17.4	15	14.6
324	Sarada	40	2	2	2	2	540	16	16.8	14	14.6
325	Kamakshi	51	2	1	2	1	543	2	19.1	17	14.6
326	Kamakshi	51	2	2	2	1	540	14	16.3	15	14.6
327	Sowmya	39	2	1	2	2	555	22	15	15	14.6
328	Sowmya	39	2	2	2	2	550	16	15.4	15	14.6
329	Gowri	60	2	1	2	2	464	12	13	9	10.2
330	Gowri	60	2	2	2	2	570	22	26.4	11	12.2
331	Neela	71	2	1	2	2	535	18	19.1	14	17.3
332	Neela	71	2	2	2	2	498	20	23.1	14	17.3
333	Rasathi	56	2	1	1	2	474	12	14.2	11	17.3
334	Rasathi	56	2	2	1	2	521	14	13.5	10	17.3
335	Murugan	54	1	1	2	2	432	8	16.8	10	10.2
336	Murugan	54	1	2	2	2	437	8	15.1	13	11.4
337	Chakkarai	61	1	1	2	2	480	10	14.3	8	17.3
338	Chakkarai	61	1	2	2	2	532	12	15.3	10	17.3
339	Raghavan	60	1	1	2	2	520	16	16.1	11	12.2
340	Raghavan	60	1	2	2	2	511	14	15	13	12.2
341	Kannappan	53	1	1	2	2	565	12	12.6	15	14.6
342	Kannappan	53	1	2	2	2	569	8	11.8	14	14.6
343	Mariappan	40	1	1	2	2	504	10	11.1	8	14.6
344	Mariappan	40	1	2	2	2	496	6	11.9	10	12.2
345	Kondaiya	47	1	1	2	2	526	14	13.1	10	17.3
346	Kondaiya	47	1	2	2	2	531	12	14.1	9	17.3
347	Balaraman	61	1	1	2	2	532	12	15.1	10	12.2
348	Balaraman	61	1	2	2	2	509	10	12.2	12	12.2
349	Mariappan	65	1	1	2	2	537	14	17.9	11	14.6
350	Mariappan	65	1	2	2	2	550	8	17.1	11	14.6
351	Murugappan	60	1	1	2	2	603	10	12	17	7.1
352	Murugappan	60	1	2	2	2	610	12	10.2	18	17.3
353	Kumar	26	1	1	2	2	633	12	15.1	11	12.2
354	Kumar	26	1	2	2	2	632	10	15.2	9	14.6
355	Nithyanand	37	1	1	2	2	593	18	19.1	15	17.3
356	Nithyanand	37	1	2	2	2	603	20	23.1	10	17.3
357	Mari	47	1	1	2	2	560	12	11.1	14	14.6
358	Mari	47	1	2	2	2	556	12	11.8	13	14.6
359	Selvam	51	1	1	2	2	529	10	15.7	12	17.3

360	Selvam	51	1	2	2	2	497	12	12.1	10	17.3
361	Meenu	60	2	1	2	2	466	8	14.1	7	12.2
362	Meenu	60	2	2	2	2	458	10	12.2	9	12.2
363	Rani	68	2	1	2	2	531	14	18.2	12	14.6
364	Rani	68	2	2	2	2	545	10	15.7	12	14.6
365	Kodai	70	2	1	2	2	624	8	16.3	12	12.2
366	Kodai	70	2	2	2	2	598	10	20.1	16	12.2
367	Revathi	72	2	1	2	2	612	10	13.2	17	12.2
368	Revathi	72	2	2	2	2	581	16	16.5	17	14.6
369	Kulandai	47	2	1	1	2	524	14	14.8	14	14.6
370	Kulandai	47	2	2	1	2	521	16	18.4	18	17.3
371	Usharani	55	2	1	2	2	510	12	13.1	12	17.3
372	Usharani	55	2	2	2	2	542	16	15.2	14	17.3
373	Gowri	45	2	1	2	2	552	16	18.2	12	17.3
374	Gowri	45	2	2	2	2	538	18	15.3	12	17.3
375	Govindammal	66	2	1	1	1	520	18	19.5	17	14.6
376	Govindammal	66	2	2	1	1	504	18	19.4	17	14.6
377	Kalyani	35	2	1	2	2	524	16	17.9	15	17.3
378	Kalyani	35	2	2	2	2	540	16	14.8	14	17.3
379	Selvi	65	2	1	2	2	504	14	14.3	13	14.6
380	Selvi	65	2	2	2	2	519	14	15.2	14	14.6
381	Rasathi	45	2	1	2	2	552	8	16.1	13	14.6
382	Rasathi	45	2	2	2	2	564	8	16.4	13	14.6
383	Lalitha	65	2	1	2	2	551	12	12.1	13	14.6
384	Lalitha	65	2	2	2	2	596	14	12.6	14	12.2
385	Meenakshi	67	2	1	1	2	525	18	15.5	13	14.6
386	Meenakshi	67	2	2	1	2	527	20	20.7	17	17.3
387	Nagaiyah	54	1	1	2	2	540	16	14.6	17	14.6
388	Nagaiyah	54	1	2	2	2	515	14	15.9	15	17.3
389	Mehamood	67	1	1	2	2	497	12	13	15	17.3
390	Mehamood	67	1	2	2	2	467	14	15.5	13	14.6
391	Gopal	53	1	1	2	2	550	10	13	10	10.2
392	Gopal	53	1	2	2	2	495	12	15	11	10.2
393	Pichandi	57	1	1	2	2	531	14	20.7	12	14.6
394	Pichandi	57	1	2	2	2	531	12	21.2	12	10.2
395	Kamalam	62	2	1	2	2	540	10	15.4	11	12.2
396	Kamalam	62	2	2	2	2	545	10	14.8	12	14.6
397	Lakshmi	58	2	1	2	1	545	8	20.6	18	17.3
398	Lakshmi	58	2	2	2	1	535	12	19.7	19	17.3
399	Janaki	50	2	1	2	2	432	12	10.9	8	14.6
400	Janaki	50	2	2	2	2	430	14	15.1	10	12.2
401	Rajeshwari	62	2	1	2	1	576	12	18.7	13	14.6
402	Rajeshwari	62	2	2	2	1	568	10	17.4	11	14.6
403	Sarala	70	2	1	2	2	424	12	14.3	9	7.1
404	Sarala	70	2	2	2	2	431	14	14.4	10	10.2
405	Kanchana	55	2	1	2	2	543	14	16.5	12	14.6
406	Kanchana	55	2	2	2	2	547	16	16.1	13	14.6
407	Ponni	60	2	1	1	2	554	12	15.2	10	17.3
408	Ponni	60	2	2	1	2	552	14	16.5	15	17.3
409	Vanmathi	60	2	1	2	1	486	10	12	9	14.6
410	Vanmathi	60	2	2	2	1	476	12	15.9	12	17.3
411	Sethu	54	1	1	2	2	620	10	8.2	11	10.2

412	Sethu	54	1	2	2	2	564	10	12.1	16	10.2
413	Kumar	70	1	1	2	2	572	14	12.4	12	8.5
414	Kumar	70	1	2	2	2	576	8	11.7	12	10.2
415	Nandini	35	2	1	2	2	558	12	15.8	14	17.3
416	Nandini	35	2	2	2	2	560	10	14	13	14.6
417	Ponnammal	45	2	1	1	2	560	18	15.1	19	14.6
418	Ponnammal	45	2	2	1	2	572	18	16.4	19	14.6
419	Latha	45	2	1	2	2	542	8	8.2	10	8.5
420	Latha	45	2	2	2	2	537	10	12.5	16	14.6
421	Shanthi	60	2	1	1	2	586	22	21	16	17.3
422	Shanthi	60	2	2	1	2	580	14	15.8	17	17.3
423	Ganesan	78	1	1	2	2	512	22	28.7	20	17.3
424	Ganesan	78	1	2	2	2	510	12	13.7	10	12.2
425	Jyothi	35	2	1	2	2	540	14	16.4	14	17.3
426	Jyothi	35	2	2	2	2	548	14	14.1	13	17.3
427	Seethammal	40	2	1	2	2	546	18	17.4	15	14.6
428	Seethammal	40	2	2	2	2	540	16	16.8	14	14.6
429	Jamuna	51	2	1	2	1	543	2	19.1	17	14.6
430	Jamuna	51	2	2	2	1	540	14	16.3	15	14.6
431	Dillibai	72	2	1	2	2	612	10	13.2	17	12.2
432	Dillibai	72	2	2	2	2	581	16	16.5	17	14.6
433	Rajathi	45	2	1	1	2	524	14	14.8	14	14.6
434	Rajathi	45	2	2	1	2	521	16	18.4	18	17.3
435	Vanathi	55	2	1	2	2	510	12	13.1	12	17.3
436	Vanathi	55	2	2	2	2	542	16	15.2	14	17.3
437	Rajeshwari	45	2	1	2	2	552	16	18.2	12	17.3
438	Rajeshwari	45	2	2	2	2	538	18	15.3	12	17.3
439	Ganga	65	2	1	1	1	520	18	19.5	17	14.6
440	Ganga	65	2	2	1	1	504	18	19.4	17	14.6
441	Chokkamal	62	2	1	1	2	560	18	15.1	19	14.6
442	Chokkamal	62	2	2	1	2	570	18	16.5	18	14.6
443	Perumal	57	1	1	2	2	540	8	8.3	10	12.2
444	Perumal	57	1	2	2	2	535	10	12.5	15	14.6
445	Bagyalakshmi	58	2	1	2	2	490	12	16.5	10	12.2
446	Bagyalakshmi	58	2	2	2	2	501	10	15	11	12.2
447	Ambika	45	2	1	1	1	530	14	18.1	14	14.6
448	Ambika	45	2	2	1	1	540	10	17.7	13	14.6
449	Maheshwari	53	2	1	2	2	517	22	22.8	20	17.3
450	Maheshwari	53	2	2	2	2	520	20	19	16	17.3
451	Deyvani	55	2	1	2	2	502	10	12.7	8	12.2
452	Deyvani	55	2	2	2	2	507	14	14.5	12	12.2
453	Kannamma	47	2	1	2	2	472	18	17.4	13	14.6
454	Kannamma	47	2	2	2	2	470	14	15.8	12	14.6
455	Andiappan	68	1	1	1	2	580	22	23.1	24	24.2
456	Andiappan	68	1	2	1	2	602	16	16.6	18	14.6
457	Lakshmiammal	65	2	1	2	2	471	6	13.3	8	10.2
458	Lakshmiammal	65	2	2	2	2	471	6	11.6	7	10.2
459	Kanchana	57	2	1	2	2	542	16	15.7	12	10.2
460	Kanchana	57	2	2	2	2	537	16	14.6	13	17.3
461	Ranga	65	1	1	2	2	537	14	17.9	11	14.6
462	Ranga	65	1	2	2	2	550	8	17.1	11	14.6
463	Padmanaban	60	1	1	2	2	603	10	12	17	7.1

464	Padmanaban	60	1	2	2	2	610	12	10.2	18	17.3
465	Natarajan	26	1	1	2	2	633	12	15.1	11	12.2
466	Natarajan	26	1	2	2	2	632	10	15.2	9	14.6
467	Suresh	37	1	1	2	2	593	18	19.1	15	17.3
468	Suresh	37	1	2	2	2	603	20	23.1	10	17.3
469	Thandavam	47	1	1	2	2	560	12	11.1	14	14.6
470	Thandavam	47	1	2	2	2	556	12	11.8	13	14.6
471	Pichandi	45	1	1	2	2	540	18	19	23	20.6
472	Pichandi	45	1	2	2	2	539	20	20	22	20.6
473	Dhanam	32	2	1	2	2	530	20	21.4	20	17.3
474	Dhanam	32	2	2	2	2	525	14	20.8	21	17.3
475	Padmanaban	65	1	1	2	2	370	12	13	9	14.6
476	Padmanaban	65	1	2	2	2	375	22	27	17	24.6
477	Dayalan	49	1	1	2	2	490	14	13.5	12	12.2
478	Dayalan	49	1	2	2	2	501	14	14.2	12	12.2
479	Ahalya	65	2	1	2	1	478	8	10.6	3	7.1
480	Ahalya	65	2	2	2	1	472	10	10.8	6	7.1
481	Nandini	65	2	1	1	2	516	16	16.8	13	14.6
482	Nandini	65	2	2	1	2	534	12	12.7	13	17.3
483	Sheela	60	2	1	1	1	502	10	16.8	15	14.6
484	Sheela	60	2	2	1	1	496	10	17.3	14	14.6
485	Seethammal	42	2	1	1	2	504	16	17.8	13	10.2
486	Seethammal	42	2	2	1	2	511	18	19.6	15	14.6
487	Kamalammal	70	2	1	2	2	498	18	19.6	13	17.3
488	Kamalammal	70	2	2	2	2	498	16	17.8	14	17.3
489	Venkatesh	40	1	1	2	2	490	12	16.5	11	12.2
490	Venkatesh	40	1	2	2	2	504	10	15.1	11	12.2
491	Rajathi	50	2	1	1	1	532	14	18.4	14	14.6
492	Rajathi	50	2	2	1	1	542	10	17.2	13	14.6
493	Ekambaram	51	1	1	2	2	542	12	12.1	8	10.2
494	Ekambaram	51	1	2	2	2	530	14	15.7	13	12.2
495	Palani	60	1	1	2	2	610	16	19.4	20	14.6
496	Palani	60	1	2	2	2	604	18	18.5	21	17.3
497	Velan	60	1	1	1	2	528	10	14.3	10	12.2
498	Velan	60	1	2	1	2	551	10	13.9	12	10.2
499	Arumugham	42	1	1	2	2	482	18	18.4	15	14.6
500	Arumugham	42	1	2	2	2	490	18	17.7	13	14.6
501	Kasthuri	39	2	1	2	2	545	22	15	15	14.6
502	Kasthuri	39	2	2	2	2	550	16	15.4	15	14.6
503	Ponnammal	60	2	1	2	2	464	12	13	9	10.2
504	Ponnammal	60	2	2	2	2	570	22	26.4	11	12.2
505	Rajathi	71	2	1	2	2	525	18	19.1	14	17.3
506	Rajathi	71	2	2	2	2	498	20	23.1	14	17.3
507	Shanthi	56	2	1	1	2	474	12	14.2	11	17.3
508	Shanthi	56	2	2	1	2	521	14	13.5	10	17.3
509	Annamalai	54	1	1	2	2	482	8	16.8	10	10.2
510	Annamalai	54	1	2	2	2	487	8	15.1	13	11.4
511	Ponni	30	2	1	2	2	524	16	17.9	15	17.3
512	Ponni	30	2	2	2	2	540	16	14.8	14	17.3
513	Valli	65	2	1	2	2	504	14	14.3	13	14.6
514	Valli	65	2	2	2	2	519	14	15.2	14	14.6
515	Mallika	45	2	1	2	2	552	8	16.1	13	14.6

516	Mallika	45	2	2	2	2	564	8	16.4	13	14.6
517	Parvathy	65	2	1	2	2	551	12	12.1	13	14.6
518	Parvathy	65	2	2	2	2	596	14	12.6	14	12.2
519	Meenu	65	2	1	1	2	525	18	15.5	13	14.6
520	Meenu	65	2	2	1	2	527	20	20.7	17	17.3
521	Maheshwari	60	2	1	1	1	565	32	30.5	33	24.4
522	Maheshwari	60	2	2	1	1	590	30	33.7	33	24.4
523	Kanchana	45	2	1	2	2	530	16	20.5	17	17.3
524	Kanchana	45	2	2	2	2	540	16	17.5	15	12.2
525	Latha	35	2	1	2	2	500	10	14.9	11	14.6
526	Latha	35	2	2	2	2	495	10	11.4	9	12.2
527	Rajeswari	52	2	1	2	2	604	8	17.4	14	12.2
528	Rajeswari	52	2	2	2	2	598	10	19.3	15	17.3
529	Thamil	66	2	1	2	2	504	22	24.9	19	17.3
530	Thamil	66	2	2	2	2	521	20	21.3	14	17.3
531	Velmurugan	70	1	1	2	2	536	24	24.7	22	17.3
532	Velmurugan	70	1	2	2	2	536	24	22.8	25	24.4
533	Unnamalai	49	2	1	2	2	516	12	13.6	14	17.3
534	Unnamalai	49	2	2	2	2	508	10	12.3	14	17.3
535	Jamuna	70	2	1	2	2	501	16	16.7	11	10.2
536	Jamuna	70	2	2	2	2	476	16	17.5	11	10.2
537	Jyothi	55	2	1	1	1	506	26	23	13	17.3
538	Jyothi	55	2	2	1	1	518	22	18.7	16	17.3
539	Uma	60	2	1	1	2	586	22	21	16	17.3
540	Uma	60	2	2	1	2	586	14	15.8	17	17.3
541	Thangavel	51	1	1	2	2	529	10	15.7	12	17.3
542	Thangavel	51	1	2	2	2	497	12	12.1	10	17.3
543	Kannamma	60	2	1	2	2	466	8	14.1	7	12.2
544	Kannamma	60	2	2	2	2	458	10	12.2	9	12.2
545	Mallika	68	2	1	2	2	531	14	18.2	12	14.6
546	Mallika	68	2	2	2	2	545	10	15.7	12	14.6
547	Deyvani	70	2	1	2	2	624	8	16.3	12	12.2
548	Deyvani	70	2	2	2	2	598	10	20.1	16	12.2
549	Ambika	72	2	1	2	2	612	10	13.2	17	12.2
550	Ambika	72	2	2	2	2	581	16	16.5	17	14.6
551	Thirumalai	48	1	1	2	1	513	12	19.5	15	17.3
552	Thirumalai	48	1	2	2	1	526	14	17.6	18	17.3
553	Natesan	43	1	1	2	2	481	8	19.1	16	17.3
554	Natesan	43	1	2	2	2	500	10	17.9	15	17.3
555	Gyanavel	45	1	1	2	2	563	26	24.9	22	17.3
556	Gyanavel	45	1	2	2	2	550	20	23.2	21	17.3
557	Venkatesan	53	1	1	2	2	526	20	21.1	22	20.6
558	Venkatesan	53	1	2	2	2	521	10	14.4	13	14.6
559	Dakshinamoorthy	57	1	1	1	2	478	18	24	16	17.3
560	Dakshinamoorthy	57	1	2	1	2	531	10	14.7	14	17.3
561	Ganga	60	2	1	2	1	493	8	16.3	14	17.3
562	Ganga	60	2	2	2	1	516	12	16.1	14	17.3
563	Bagyalakshmi	67	2	1	2	1	543	10	16.8	10	12.2
564	Bagyalakshmi	67	2	2	2	1	564	12	22.6	18	12.2
565	Vanathi	80	2	1	2	2	569	12	12.3	9	12.2
566	Vanathi	80	2	2	2	2	540	8	16.3	10	17.3
567	Sheela	42	2	1	2	2	541	16	17.9	18	12.2

568	Sheela	42	2	2	2	2	513	14	17.3	15	14.6
569	Chokkamal	80	2	1	2	2	490	12	8.7	15	17.3
570	Chokkamal	80	2	2	2	2	463	14	14.3	13	14.6
571	Fathima	58	2	1	1	2	492	12	16.1	10	8.5
572	Fathima	58	2	2	1	2	507	14	15	13	14.6
573	Gopal	55	1	1	2	2	535	12	15.7	10	17.3
574	Gopal	55	1	2	2	2	547	20	23.3	15	29
575	Basha	44	1	1	2	2	525	12	17.2	13	12.2
576	Basha	44	1	2	2	2	532	12	16.4	14	12.2
577	Dakshayini	20	2	1	2	2	646	14	15.4	14	14.6
578	Dakshayini	20	2	2	2	2	550	16	13	11	12.2
579	Padma	52	2	1	2	2	528	10	17.3	12	14.6
580	Padma	52	2	2	2	2	527	12	18.2	16	17.3
581	Desikan	54	1	1	2	2	540	16	14.6	17	14.6
582	Desikan	54	1	2	2	2	515	14	15.9	15	17.3
583	Chokkalingam	67	1	1	2	2	497	12	13	15	17.3
584	Chokkalingam	67	1	2	2	2	467	14	15.5	13	14.6
585	Mehamood	54	1	1	2	2	550	10	13	10	10.2
586	Mehamood	54	1	2	2	2	495	12	15	11	10.2
587	Pichaye	57	1	1	2	2	531	14	20.7	12	14.6
588	Pichaye	57	1	2	2	2	531	12	21.2	12	10.2
589	Angammal	60	2	1	2	2	540	10	15.4	11	12.2
590	Angammal	60	2	2	2	2	545	10	14.8	12	14.6
591	Chinnathay	50	2	1	2	2	574	12	14.3	15	17.3
592	Chinnathay	50	2	2	2	2	580	16	15.9	16	12.2
593	Ellaiammal	47	2	1	1	2	481	22	22.2	16	20.6
594	Ellaiammal	47	2	2	1	2	508	18	19.7	15	20.6
595	Gunaseelan	55	1	1	2	2	554	16	14	13	10.2
596	Gunaseelan	55	1	2	2	2	539	12	14	12	14.6
597	Krishnaveni	45	2	1	2	2	582	16	16.2	13	14.6
598	Krishnaveni	45	2	2	2	2	584	12	12.3	12	14.6
599	Kuppammal	75	2	1	2	2	604	10	11.9	6	12.2
600	Kuppammal	75	2	2	2	2	554	8	13.5	8	12.2
601	Sambandam	78	1	1	2	2	519	22	28.7	20	17.3
602	Sambandam	78	1	2	2	2	510	12	13.7	10	12.2
603	Nandini	35	2	1	2	2	540	14	16.4	14	17.3
604	Nandini	35	2	2	2	2	558	14	14.1	13	17.3
605	Latha	40	2	1	2	2	566	18	17.4	15	14.6
606	Latha	40	2	2	2	2	540	16	16.8	14	14.6
607	Jyothi	51	2	1	2	1	543	2	19.1	17	14.6
608	Jyothi	51	2	2	2	1	540	14	16.3	15	14.6
609	Ambika	39	2	1	2	2	555	22	15	15	14.6
610	Ambika	39	2	2	2	2	550	16	15.4	15	14.6
611	Valli	47	2	1	1	2	524	14	14.8	14	14.6
612	Valli	47	2	2	1	2	521	16	18.4	18	17.3
613	Parvathy	55	2	1	2	2	510	12	13.1	12	17.3
614	Parvathy	55	2	2	2	2	542	16	15.2	14	17.3
615	Maheshwari	45	2	1	2	2	552	16	18.2	12	17.3
616	Maheshwari	45	2	2	2	2	538	18	15.3	12	17.3
617	Vanmathi	66	2	1	1	1	520	18	19.5	17	14.6
618	Vanmathi	66	2	2	1	1	504	18	19.4	17	14.6
619	Minnal	35	2	1	2	2	524	16	17.9	15	17.3

620	Minnal	35	2	2	2	2	540	16	14.8	14	17.3
621	Anbu	42	1	1	2	2	495	8	12.9	11	10.2
622	Anbu	42	1	2	2	2	490	8	13.9	12	12.2
623	Chinnakuzhandai	75	2	1	2	2	485	26	28.8	25	29
624	Chinnakuzhandai	75	2	2	2	2	474	10	13	7	17.3
625	Murthy	34	1	1	2	2	524	26	25.1	29	29
626	Murthy	34	1	2	2	2	535	34	33.6	35	34.5
627	Kandhasamy	28	1	1	2	2	566	12	13	12	12.2
628	Kandhasamy	28	1	2	2	2	566	10	13.5	14	12.2
629	Govindan	60	1	1	2	2	495	10	13.1	10	10.2
630	Govindan	60	1	2	2	2	485	6	9	6	10.2
631	Pattammal	75	2	1	2	2	553	10	13.1	10	10.2
632	Pattammal	75	2	2	2	2	490	8	15.3	11	10.2
633	Mariammal	55	2	1	2	2	531	14	15.6	12	14.6
634	Mariammal	55	2	2	2	2	533	12	15.3	12	14.6
635	Yogam	70	2	1	2	2	541	10	12.9	11	12.2
636	Yogam	70	2	2	2	2	555	12	14.9	13	12.2
637	Nagammal	60	2	1	2	1	544	8	20.6	19	17.3
638	Nagammal	60	2	2	2	1	536	12	21.1	19	17.3
639	Rajeshwari	45	2	1	2	2	432	12	15.4	8	14.6
640	Rajeshwari	45	2	2	2	2	430	12	14.9	10	12.2
641	Ahalya	60	2	1	2	2	468	12	17.3	11	17.3
642	Ahalya	60	2	2	2	2	474	12	13.5	11	17.3
643	Muniammal	55	2	1	2	2	502	10	12.7	8	12.2
644	Muniammal	55	2	2	2	2	507	14	14.5	12	12.2
645	Desammal	47	2	1	2	2	472	18	17.4	13	14.6
646	Desammal	47	2	2	2	2	470	14	15.8	12	14.6
647	Devan	68	1	1	1	2	580	22	23.1	24	24.2
648	Devan	68	1	2	1	2	602	16	16.6	18	14.6
649	Barbara	65	2	1	2	2	471	6	13.3	8	10.2
650	Barbara	65	2	2	2	2	471	6	11.6	7	10.2
651	Rajesh	61	1	1	2	2	532	12	15.1	10	12.2
652	Rajesh	61	1	2	2	2	509	10	12.2	12	12.2
653	Abdullah	65	1	1	2	2	527	14	17.9	11	14.6
654	Abdullah	65	1	2	2	2	550	8	17.1	11	14.6
655	Marimuthu	60	1	1	2	2	603	10	12	17	7.1
656	Marimuthu	60	1	2	2	2	610	12	10.2	18	17.3
657	Rehamatullah	26	1	1	2	2	603	12	15.1	11	12.2
658	Rehamatullah	26	1	2	2	2	612	10	15.2	9	14.6
659	Muthu	37	1	1	2	2	593	18	19.1	15	17.3
660	Muthu	37	1	2	2	2	603	20	23.1	10	17.3
661	Rani	58	2	1	2	1	545	8	20.6	18	17.3
662	Rani	58	2	2	2	1	535	12	19.7	19	17.3
663	Mary	48	2	1	2	2	432	12	10.9	8	14.6
664	Mary	48	2	2	2	2	430	14	15.1	10	12.2
665	Gangammal	52	2	1	2	2	540	16	11.9	19	17.3
666	Gangammal	52	2	2	2	2	530	16	17.5	16	14.6
667	Bhuvaneswari	49	2	1	2	2	460	8	10.9	12	10.2
668	Bhuvaneswari	49	2	2	2	2	470	10	12.2	11	12.2
669	Kaveri	39	2	1	2	2	530	8	13.1	8	14.6
670	Kaveri	39	2	2	2	2	535	6	11.7	15	12.2
671	Ganapathy	63	1	1	2	2	596	16	18.8	15	17.3

672	Ganapathy	63	1	2	2	2	598	12	22.7	27	17.3
673	Sarala	50	2	1	1	2	533	16	16.6	15	17.3
674	Sarala	50	2	2	1	2	530	16	15.3	13	17.3
675	Ponnammal	58	2	1	2	2	512	12	15.8	10	12.2
676	Ponnammal	58	2	2	2	2	534	20	20.7	20	17.2
677	Shanthi	65	2	1	2	2	570	20	15.8	15	14.6
678	Shanthi	65	2	2	2	2	575	18	14.2	16	17.3
679	Rajathi	57	2	1	1	2	488	14	15.5	11	14.6
680	Rajathi	57	2	2	1	2	498	12	13.7	9	14.6
681	Kannamma	60	2	1	2	2	464	12	13	9	10.2
682	Kannamma	60	2	2	2	2	570	22	26.4	11	12.2
683	Bagyalakshmi	71	2	1	2	2	535	18	19.1	14	17.3
684	Bagyalakshmi	71	2	2	2	2	498	20	23.1	14	17.3
685	Jamuna	56	2	1	1	2	474	12	14.2	11	17.3
686	Jamuna	56	2	2	1	2	521	14	13.5	10	17.3
687	Kandan	54	1	1	2	2	432	8	16.8	10	10.2
688	Kandan	54	1	2	2	2	437	8	15.1	13	11.4
689	Venkatachalam	61	1	1	2	2	480	10	14.3	8	17.3
690	Venkatachalam	61	1	2	2	2	532	12	15.3	10	17.3
691	Seethammal	65	2	1	2	2	504	14	14.3	13	14.6
692	Seethammal	65	2	2	2	2	519	14	15.2	14	14.6
693	Vanathi	45	2	1	2	2	552	8	16.1	13	14.6
694	Vanathi	45	2	2	2	2	564	8	16.4	13	14.6
695	Jyothi	65	2	1	2	2	551	12	12.1	13	14.6
696	Jyothi	65	2	2	2	2	596	14	12.6	14	12.2
697	Sheela	67	2	1	1	2	525	18	15.5	13	14.6
698	Sheela	67	2	2	1	2	527	20	20.7	17	17.3
699	Murugan	54	1	1	2	2	540	16	14.6	17	14.6
700	Murugan	54	1	2	2	2	515	14	15.9	15	17.3
701	Latha	50	2	1	1	2	532	14	17.7	14	17.3
702	Latha	50	2	2	1	2	530	14	14.3	14	24.4
703	Chokkamal	42	2	1	2	2	550	10	11.4	10	12.2
704	Chokkamal	42	2	2	2	2	546	12	10.1	12	12.2
705	Ponnammal	55	2	1	1	2	495	12	12.6	9	10.2
706	Ponnammal	55	2	2	1	2	516	12	12.6	11	10.2
707	Mehamood	60	1	1	2	2	490	10	21.6	13	14.6
708	Mehamood	60	1	2	2	2	530	8	9.8	7	10.2
709	Rajathi	61	2	1	2	1	510	16	13.8	12	20.6
710	Rajathi	61	2	2	2	1	505	14	17.4	14	14.6
711	Annamalai	53	1	1	2	2	541	16	20.6	19	17.3
712	Annamalai	53	1	2	2	2	532	16	19.6	17	14.6
713	Raman	73	1	1	2	2	360	8	10.9	12	8.5
714	Raman	73	1	2	2	2	470	10	15.1	10	14.6
715	Ezhumalai	62	1	1	2	2	530	8	11.6	8	10.2
716	Ezhumalai	62	1	2	2	2	534	6	17.8	14	10.2
717	Thirumalai	55	1	1	2	2	511	10	10.8	10	14.6
718	Thirumalai	55	1	2	2	2	512	26	42.2	33	29
719	Palani	47	1	1	1	2	521	48	48	55	42.1
720	Palani	47	1	2	1	2	504	10	18	19	14.6
721	Rajam	57	2	1	2	2	542	16	15.7	12	10.2
722	Rajam	57	2	2	2	2	537	16	14.6	13	17.3
723	Chidambaram	70	1	1	2	2	536	24	24.7	22	17.3

724	Chidambaram	70	1	2	2	2	536	24	22.8	25	24.4
725	Kanchana	49	2	1	2	2	516	12	13.6	14	17.3
726	Kanchana	49	2	2	2	2	508	10	12.3	14	17.3
727	Ponni	70	2	1	2	2	501	16	16.7	11	10.2
728	Ponni	70	2	2	2	2	476	16	17.5	11	10.2
729	Ganga	55	2	1	1	1	506	26	23	13	17.3
730	Ganga	55	2	2	1	1	518	22	18.7	16	17.3
731	Govindaraj	67	1	1	2	2	497	12	13	15	17.3
732	Govindaraj	67	1	2	2	2	467	14	15.5	13	14.6
733	Veerasamy	53	1	1	2	2	550	10	13	10	10.2
734	Veerasamy	53	1	2	2	2	495	12	15	11	10.2
735	Nanjaan	57	1	1	2	2	531	14	20.7	12	14.6
736	Nanjaan	57	1	2	2	2	531	12	21.2	12	10.2
737	Alamelu	62	2	1	2	2	540	10	15.4	11	12.2
738	Alamelu	62	2	2	2	2	545	10	14.8	12	14.6
739	Ahalya	58	2	1	2	1	545	8	20.6	18	17.3
740	Ahalya	58	2	2	2	1	535	12	19.7	19	17.3
741	Karpakam	50	2	1	2	2	432	12	10.9	8	14.6
742	Karpakam	50	2	2	2	2	430	14	15.1	10	12.2
743	Pakkiri	60	1	1	2	2	520	16	16.1	11	12.2
744	Pakkiri	60	1	2	2	2	511	14	15	13	12.2
745	Shankar	53	1	1	2	2	565	12	12.6	15	14.6
746	Shankar	53	1	2	2	2	569	8	11.8	14	14.6
747	Govindaraj	40	1	1	2	2	504	10	11.1	8	14.6
748	Govindaraj	40	1	2	2	2	496	6	11.9	10	12.2
749	Buhari	47	1	1	2	2	526	14	13.1	10	17.3
750	Buhari	47	1	2	2	2	531	12	14.1	9	17.3
751	Chandran	61	1	1	2	2	532	12	15.1	10	12.2
752	Chandran	61	1	2	2	2	509	10	12.2	12	12.2
753	Vijaya	67	2	1	1	2	527	12	15.6	8	8.5
754	Vijaya	67	2	2	1	2	477	14	13.5	7	8.5
755	Ravi	33	1	1	2	2	508	14	18	13	17.3
756	Ravi	33	1	2	2	2	510	14	16.2	17	17.3
757	Kamala	50	2	1	2	2	536	14	18.9	13	14.6
758	Kamala	50	2	2	2	2	540	12	17.8	14	14.6
759	Mohan	59	1	1	2	2	556	12	18.1	14	14.6
760	Mohan	59	1	2	2	2	534	14	21.7	18	17.3
761	Ahalya	60	2	1	2	2	468	12	17.3	11	17.3
762	Ahalya	60	2	2	2	2	474	12	13.5	11	17.3
763	Sarala	47	2	1	2	2	501	10	10.7	10	14.6
764	Sarala	47	2	2	2	2	502	26	42.2	33	29
765	Nandini	45	2	1	1	2	521	48	48	56	42.1
766	Nandini	45	2	2	1	2	507	10	18.1	20	14.6
767	Vanmathi	56	2	1	2	2	620	10	8.2	11	10.2
768	Vanmathi	56	2	2	2	2	564	12	12.1	15	12.2
769	Ekantham	48	1	1	2	2	570	14	12.4	12	8.5
770	Ekantham	48	1	2	2	2	575	8	11.5	11	10.2
771	Munusamy	65	1	1	2	2	555	12	15.7	14	17.3
772	Munusamy	65	1	2	2	2	560	10	14.3	14	14.6
773	Somasundaram	47	1	1	2	2	560	12	11.1	14	14.6
774	Somasundaram	47	1	2	2	2	556	12	11.8	13	14.6
775	Ekambaram	51	1	1	2	2	529	10	15.7	12	17.3

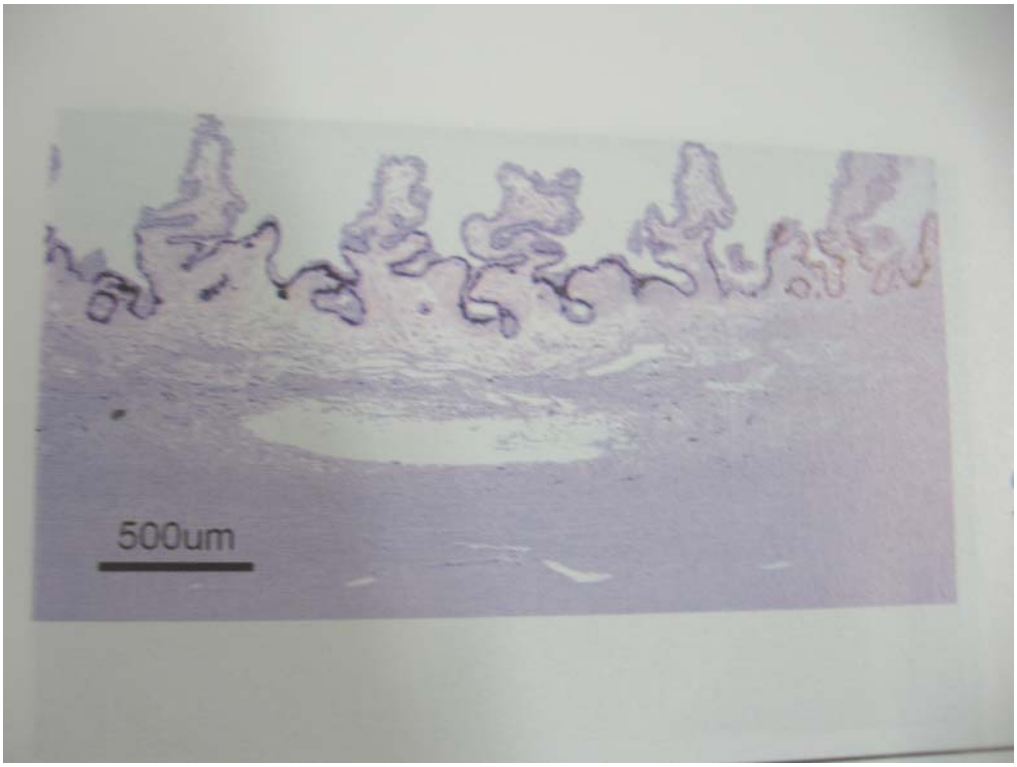
776	Ekambaram	51	1	2	2	2	497	12	12.1	10	17.3
777	Kamala	60	2	1	2	2	466	8	14.1	7	12.2
778	Kamala	60	2	2	2	2	458	10	12.2	9	12.2
779	Shankari	67	2	1	2	2	531	14	18.2	12	14.6
780	Shankari	67	2	2	2	2	545	10	15.7	12	14.6
781	Govindammal	70	2	1	2	2	624	8	16.3	12	12.2
782	Govindammal	70	2	2	2	2	598	10	20.1	16	12.2
783	Ranganayaki	57	2	1	2	2	542	16	15.7	12	10.2
784	Ranganayaki	57	2	2	2	2	537	16	14.6	13	17.3
785	Polachi	70	1	1	2	2	536	24	24.7	22	17.3
786	Polachi	70	1	2	2	2	536	24	22.8	25	24.4
787	Lakshmiammal	49	2	1	2	2	516	12	13.6	14	17.3
788	Lakshmiammal	49	2	2	2	2	508	10	12.3	14	17.3
789	Rani	70	2	1	2	2	501	16	16.7	11	10.2
790	Rani	70	2	2	2	2	476	16	17.5	11	10.2
791	Shakuntala	55	2	1	1	1	506	26	23	13	17.3
792	Shakuntala	55	2	2	1	1	518	22	18.7	16	17.3
793	Indrani	65	2	1	2	2	525	12	13.7	11	14.6
794	Indrani	65	2	2	2	2	525	14	13.8	12	14.6
795	Subbammal	65	2	1	2	2	444	14	14.6	12	8.5
796	Subbammal	65	2	2	2	2	468	12	15.4	10	10.2
797	Mohana	60	2	1	2	2	502	8	14.8	10	10.2
798	Mohana	60	2	2	2	2	500	16	17.2	11	18.9
799	Anusuya	45	2	1	2	2	542	12	14.9	15	12.2
800	Anusuya	45	2	2	2	2	556	14	12.4	13	12.2

KEY :

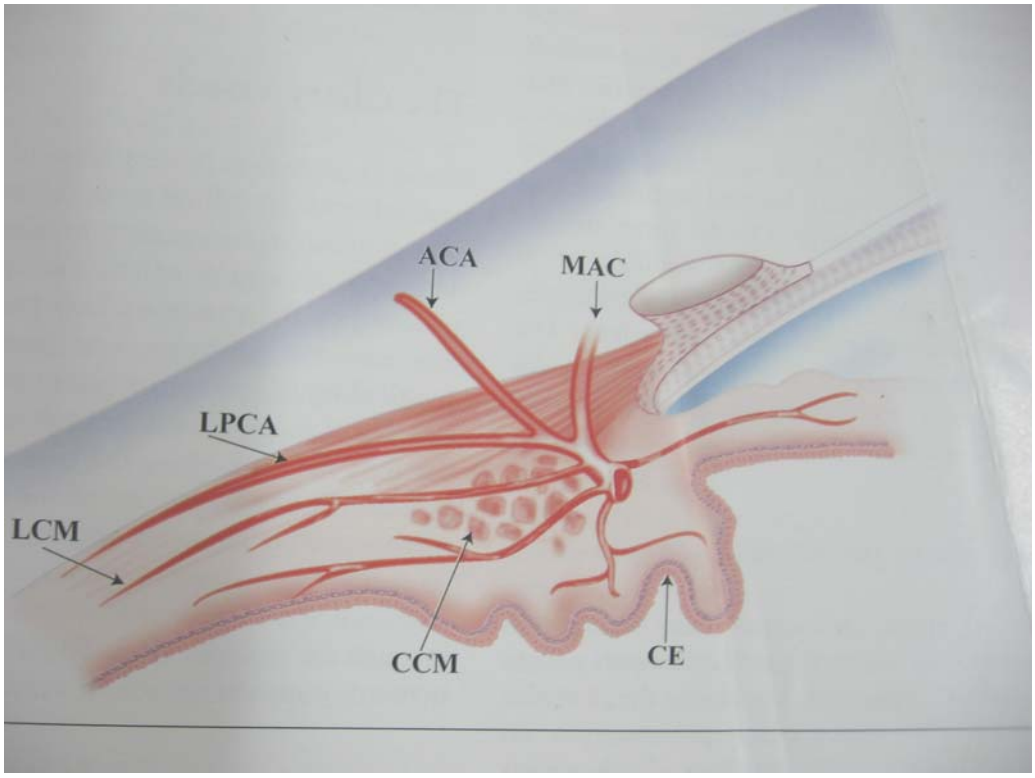
Male	1
Female	2
Right eye	1
Left eye	2
Present	1
Absent	2
Method 1	Perkins Tonometer
Method 2	Pascal Tonometer
Method 3	Non contact Tonometer
Method 4	Schiotz Tonometer

LIST OF SURGERIES PERFORMED

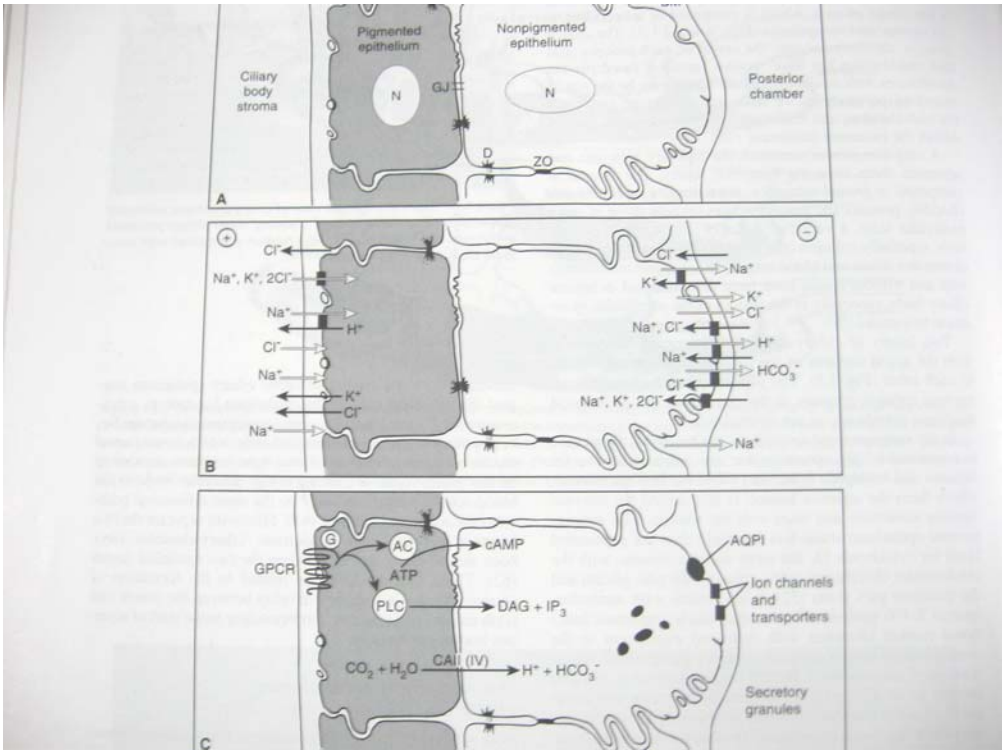
Sl. No.	Name	Sex	Age	Hosp.No.	Diagnosis	Date of surgery	Type of surgery
1	Saritha	F	15	31746	Chalazion OD	02.08.05	Incision & Curettage
2	Ekanthan	M	57	396027	Nuclear cataract OD	29.09.05	ECCE with PCIOL
3	Natesan	M	30	32146	Pterygium OS	18.10.05	Pterygium excision
4	Subbammal	F	56	399905	Mature cataract OS	08.03.06	ECCE with PCIOL
5	Munusamy	M	57	34275	Panophthalmitis OD	21.03.06	Evisceration
6	Pattammal	F	52	400314	Lagophthalmos (VII nerve palsy) OD	27.03.06	Lateral tarsorrhaphy
7	Ranganayaki	F	57	401352	Hypermature (Morgagnian) cataract OS	19.04.06	ECCE with PCIOL
8	Katammal	F	60	31762	Lagophthalmos (VII nerve palsy) OS	16.05.06	Lateral tarsorrhaphy
9	Kosammal	F	52	42750	Chronic dacryocystitis OD	26.07.06	Dacryocystectomy
10	Mohamed Abdullah	M	70	413004	Immature cataract OD	28.07.06	SICS with PCIOL
11	Fathima	F	35	405462	Non healing fungal corneal ulcer OS	17.08.06	Therapeutic Keratoplasty
12	Ettappan	M	62	413172	Panophthalmitis OD	21.10.06	Evisceration
13	Lakshmanan	M	49	45921	Decematocele OS	30.07.07	Gundersen’s flap
14	Aravind	M	40	460153	Wart lower lid OD	30.07.07	Excision
15	Vasanthi	F	72	422071	Immature cataract OS	01.08.07	SICS with PCIOL
16	Anjalai	F	50	423792	Chronic dacryocystitis OD	13.08.07	Dacryocystorhinostomy
17	Sarala	F	53	424097	POAG with Nuclear cataract OD	12.09.07	ECCE with Trabeculectomy
18	Divya	F	34	424201	Pterygium OD	24.09.07	Pterygium excision with autograft
19	Angammal	F	60	424563	Immature cataract OD	3.10.07	SICS with PCIOL
20	Ponni	F	55	424917	Mature Cataract OS	17.10.07	SICS with PCIOL



Microscopic structure of Ciliary body epithelium



Blood supply of ciliary process



Aqueous Humor formation

Aqueous Humor drainage

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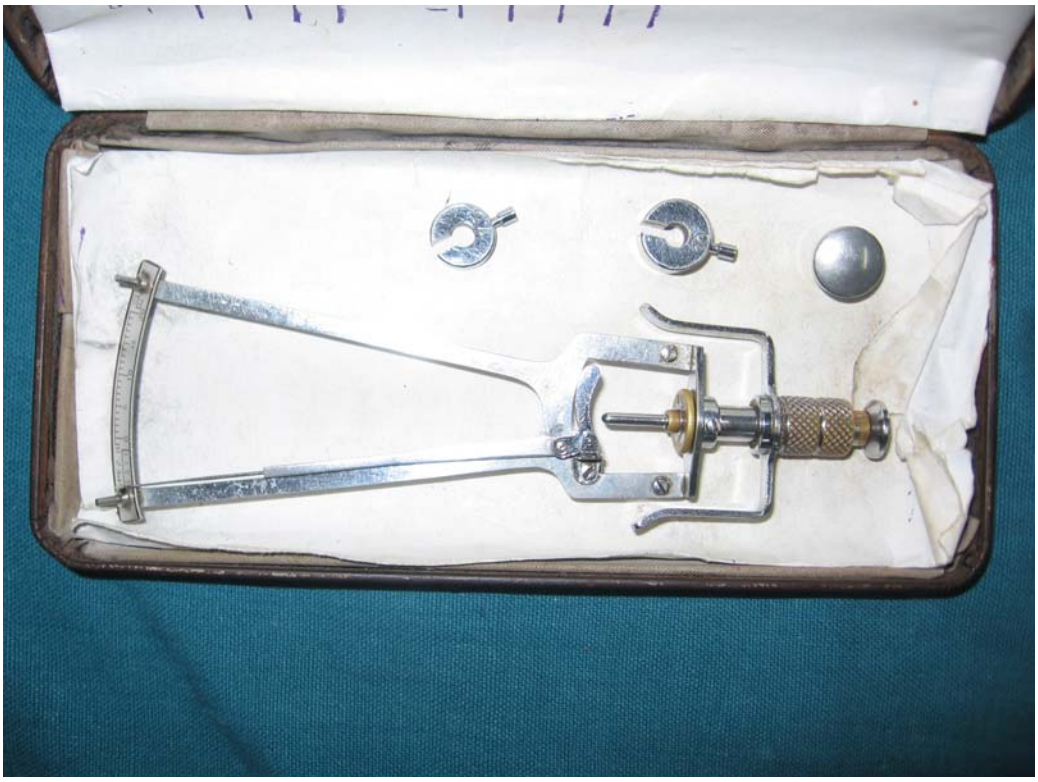
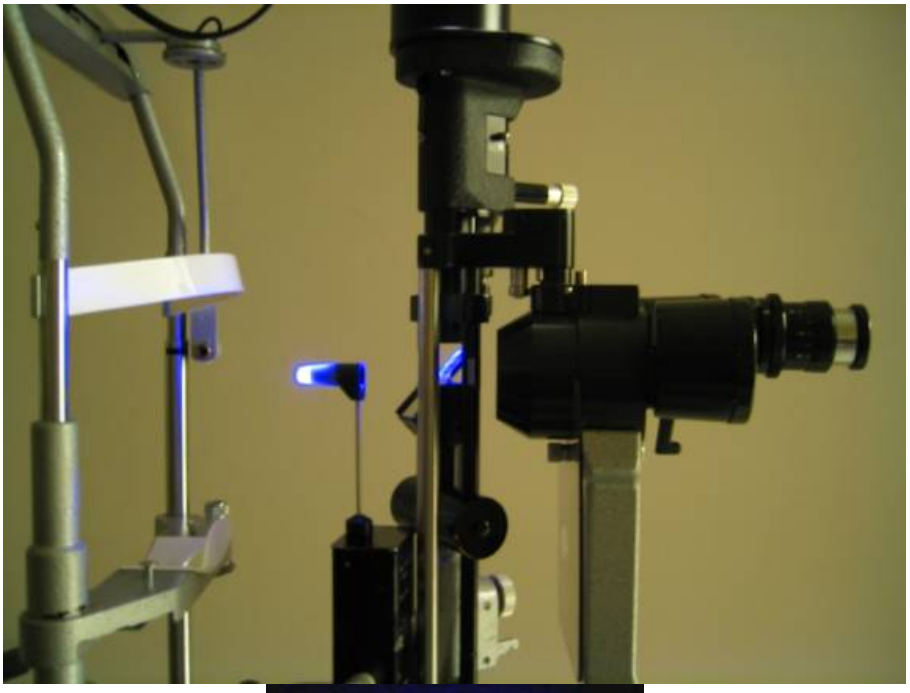
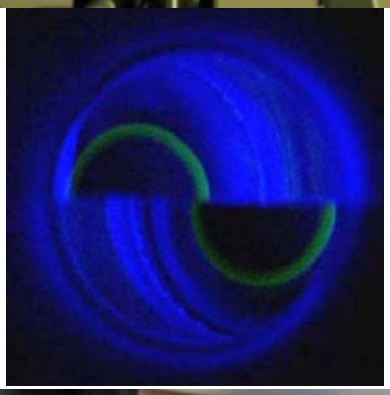
Von Graefe’s tonometer

Donder’s tonometer



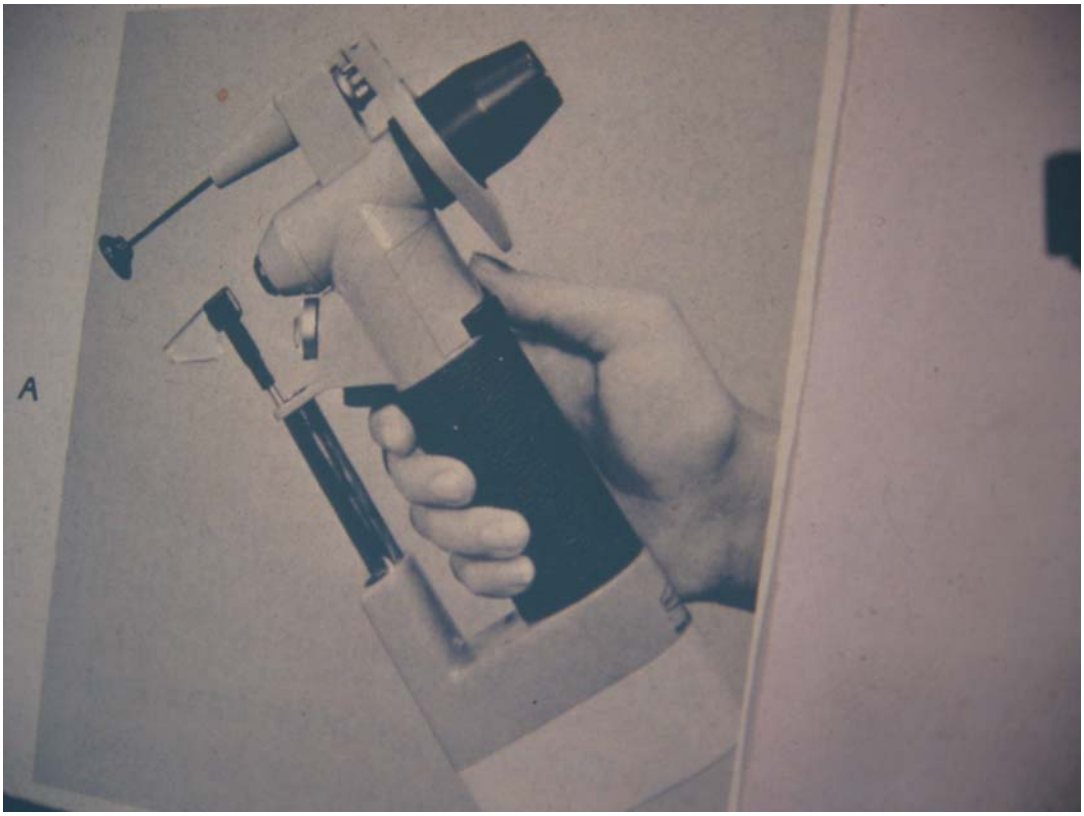
Schiotz tonometer





Goldman applanation tonometer

Perkins hand held applanation tonometer



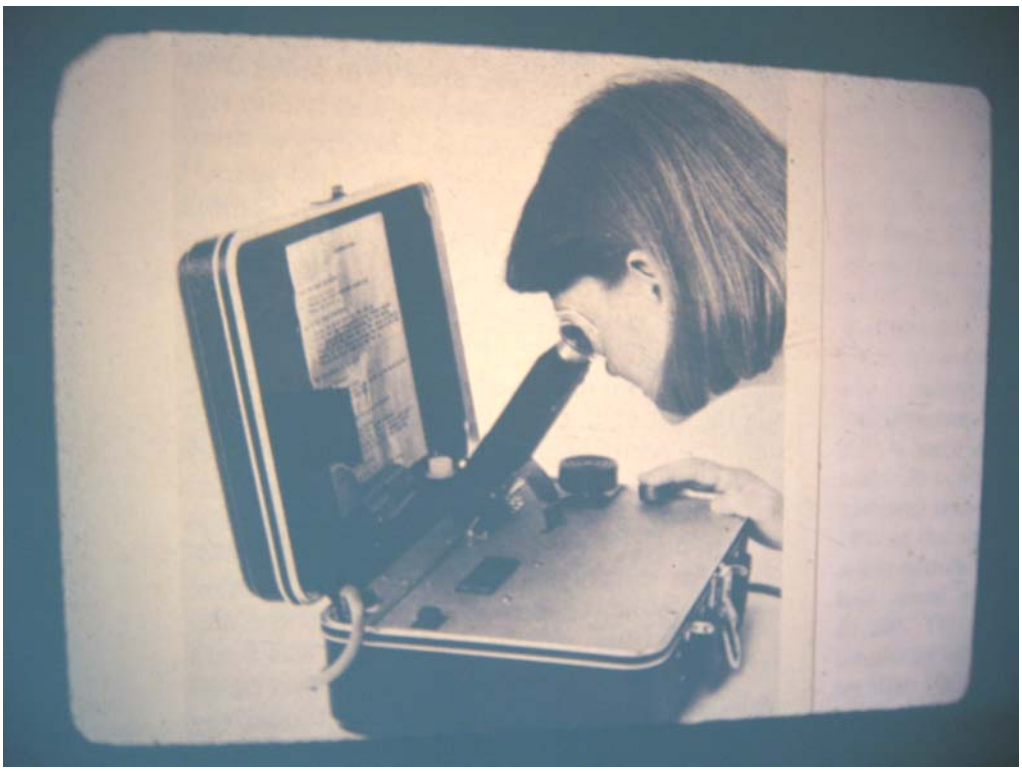
Draeger applanation tonometer

Mackay-Marg tonometer

Tono pen

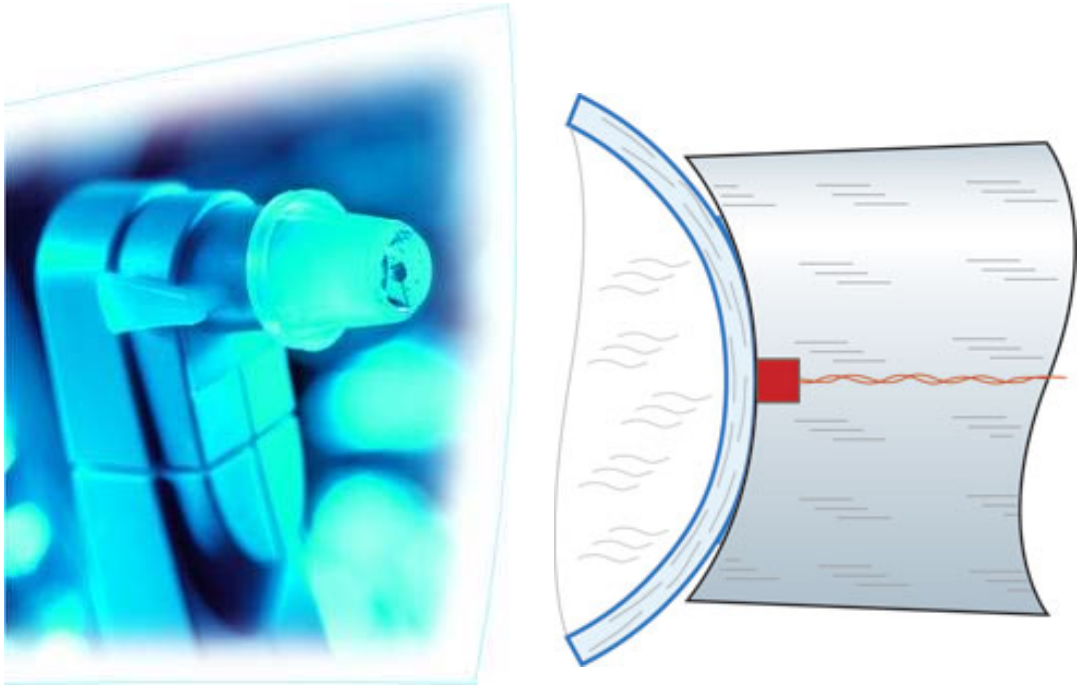
Non contact tonometer

Maklakov applanation tonometer



Home tonometer

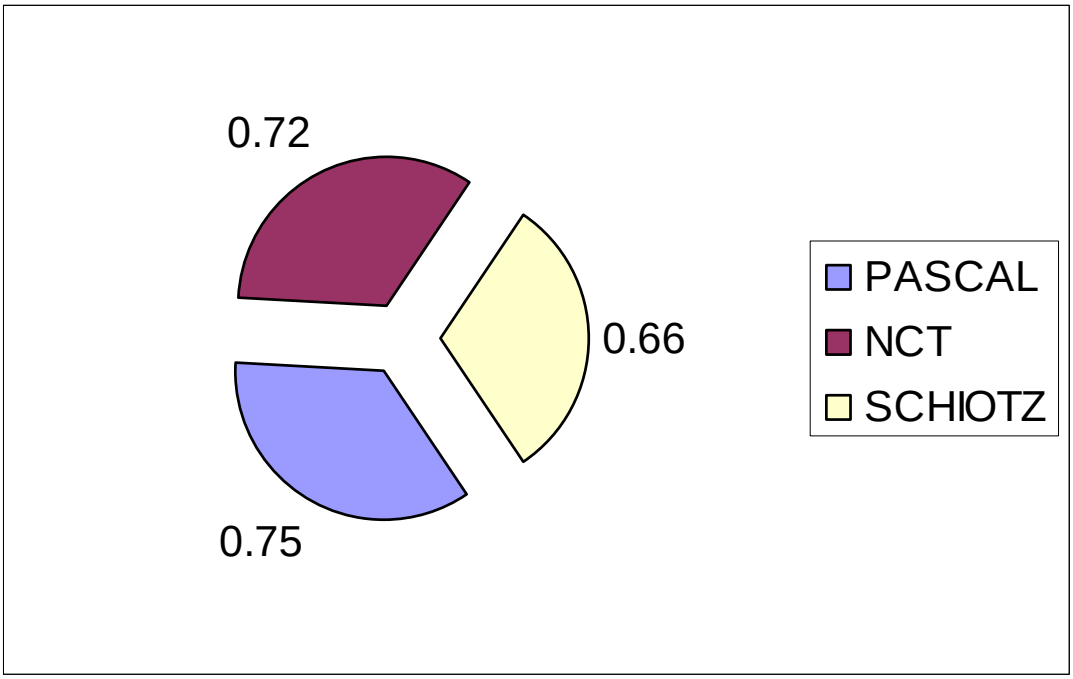
Pascal Dynamic Contour Tonometer



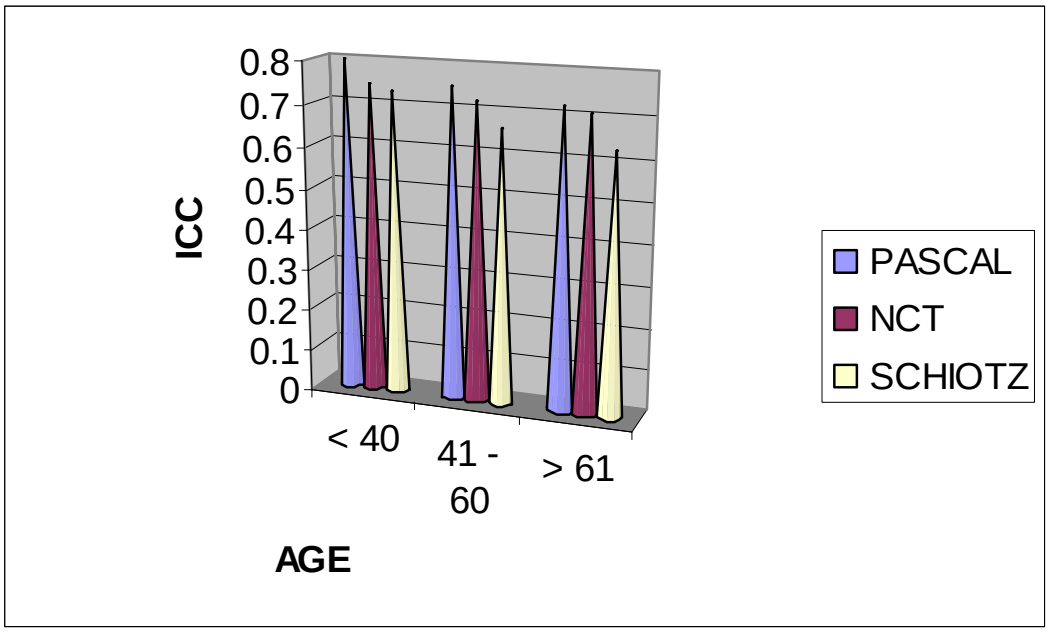
Pascal DCT contour matching tip

Reichert Ocular Response Analyser

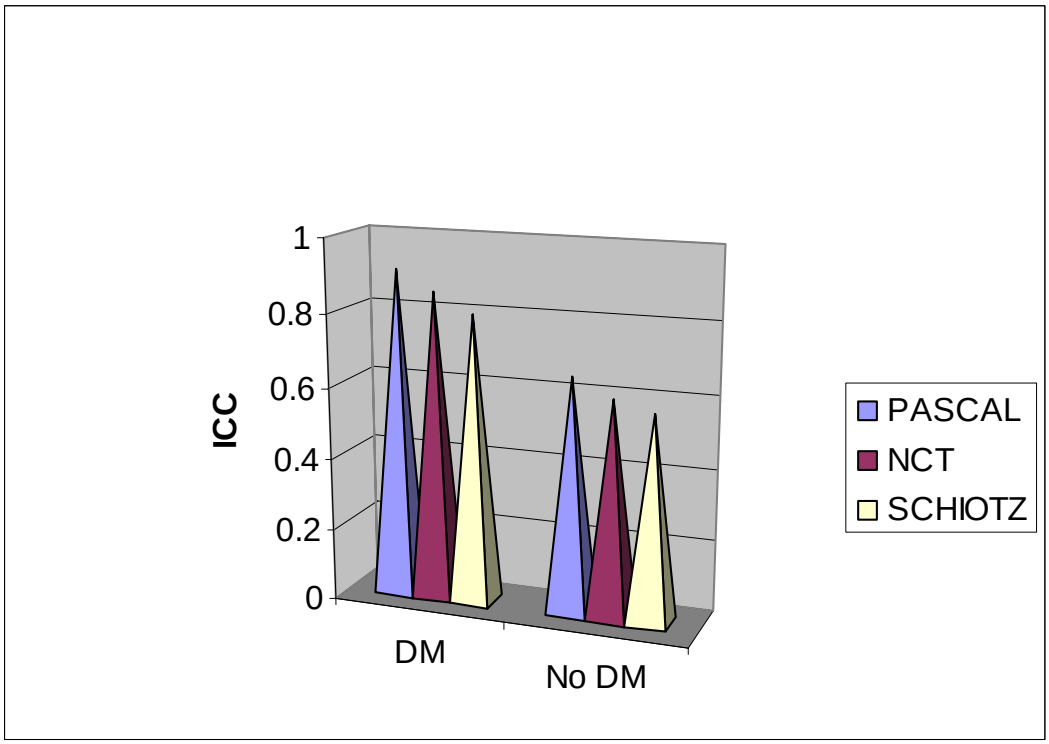
OVERALL CORRELATION BETWEEN TONOMETERS



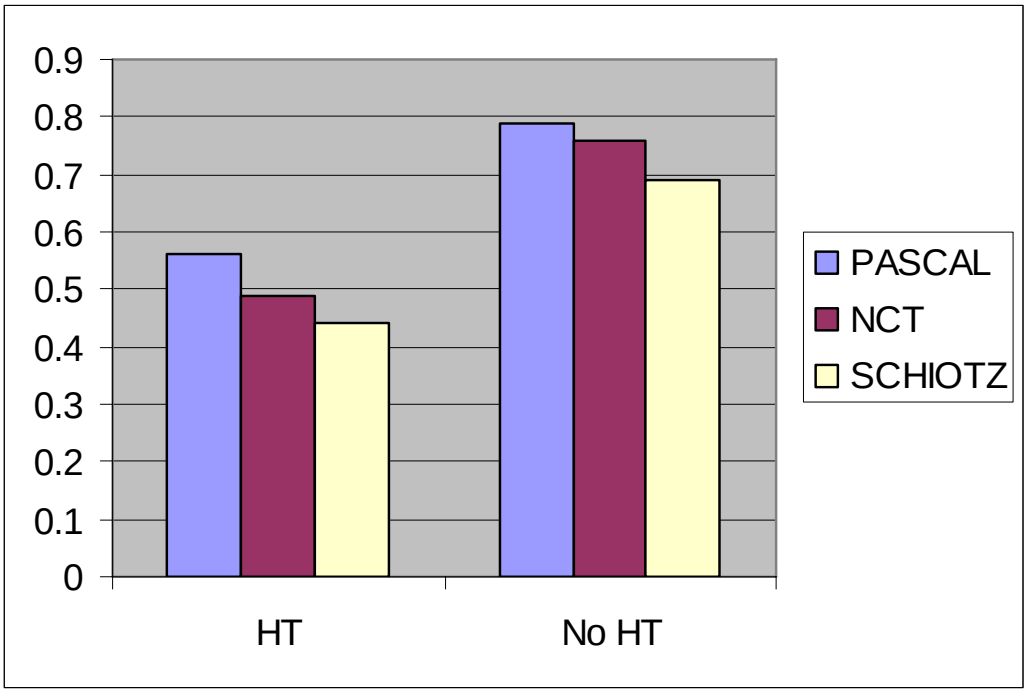
CORRELATION IN DIFFERENT AGE GROUPS



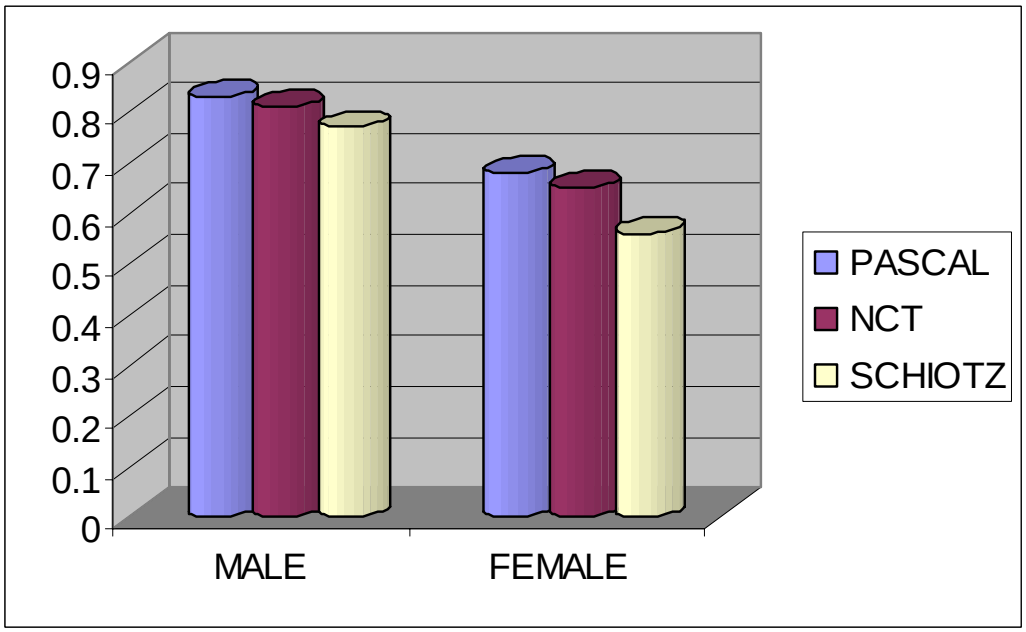
CORRELATION IN DAIBETICS AND NON DIABETICS



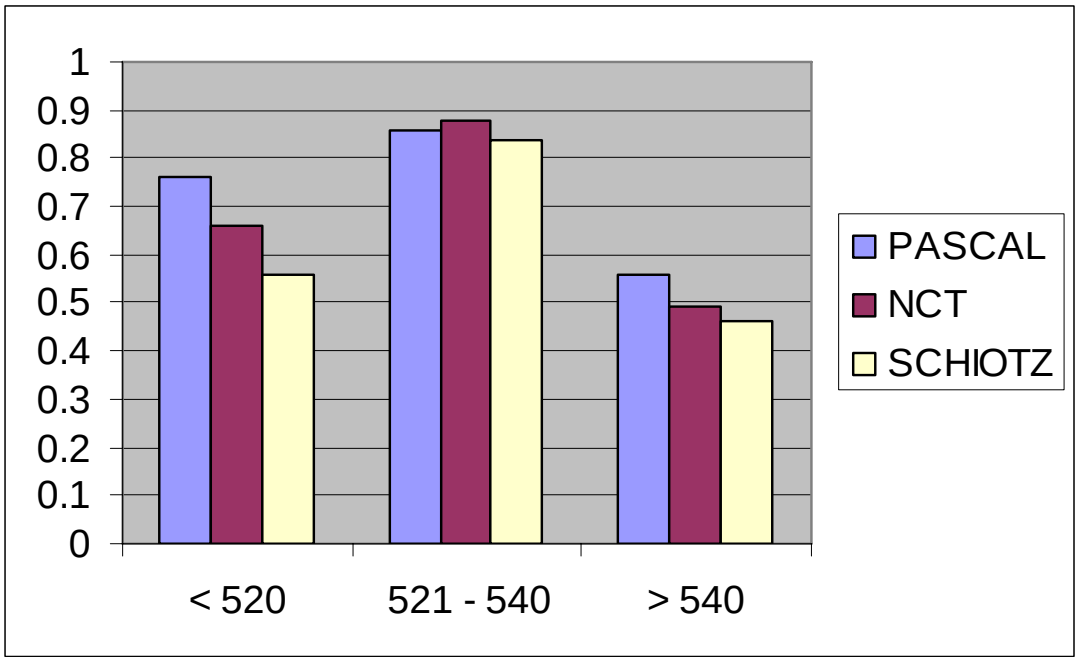
CORRELATION IN HYPERTENSIVES AND NON HYPERTENSIVES



CORRELATION IN MALES AND FEMALES



CORRELATION IN DIFFERENT CCT RANGES



CORRELATION IN DIFFERENT IOP RANGES